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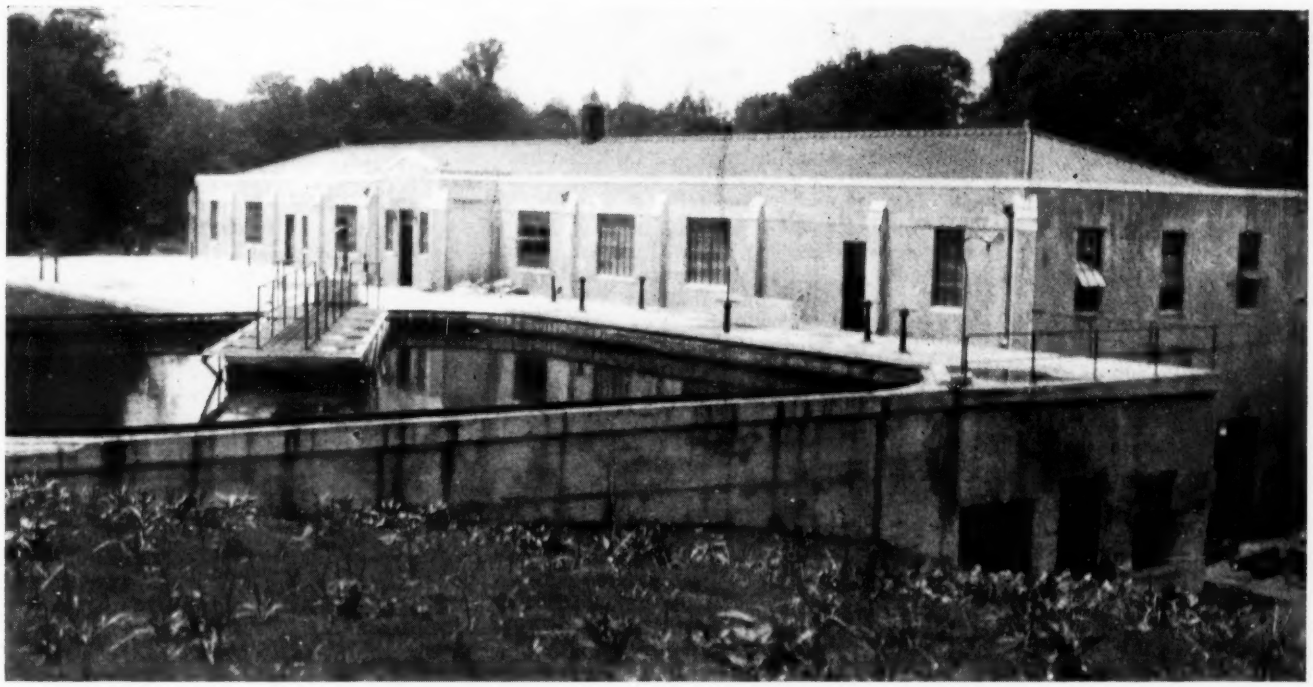

New Filtration Plant of Westchester Joint Water Works No. 1

Ferric Iron Coagulation at Mamaroneck, N. Y.

Successful Results of Experimental Runs at New Filter Plant Upon Water Resistant to Ordinary Methods of Purification Led to Continuance of Use of Ferric Iron

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THIS plant, recently constructed for the Westchester Joint Water Works No. 1, serves the Towns of Harrison and Mamaroneck, the Villages of Mamaroneck and Pelham and portions of Rye and New Rochelle in Westchester County, New York.

Features Controlling Design. — The improvement was made to an existing plant supplying water to the various communities. The distributing system was without storage reserve; therefore, all changes, additions and betterments had to be made without shut down or stoppage of the pumps.

All new work had to be incorporated as part of the existent plant using such space as was available within the building, including space utilized by the pressure filter. The pressure filters had to be maintained in service until replaced by the new filters, following this they had to be removed and the building housing them converted into a 2-story chemical house. The new filters, filter house and settling basin had to be constructed on an irregularly shaped, rock outcrop of limited area, available around this pumping station.

The Mamaroneck River water was known to be difficult to treat. This stream, derived from a small watershed, without impounding reservoirs, represented practically a straight run-off, hence flashy, with rapid variations in chemical characteristics, color, turbidity, odor and taste. Its pH value is erratic; in general it is a soft, aggressive water, containing iron and manganese and possessed of a color or stain resistant to chemical treatment. Two impounding dams now under construction, on the watershed, will modify and correct these difficulties to a considerable extent.

Capacity of the filter plant is 5 M.G.D. with provision for expansion to an ultimate capacity of 10 M.G.D. All references that follow relative to retention time periods are based on this 5 M.G.D. rate.

This watershed, some 8.75 miles long with a total gathering extent of some 14.46 square miles is taxed to its limit to furnish this yield. This high yield, however, is based upon deficiency of stream flow during dry periods being compensated by diversion from New York City's reserve storage in Rye Lake (Kensico Reservoir).

Influence of these factors is responsible for a design of plant of wide elasticity in operation with provision to allow for variations in both chemical treatment and its application.

Water Treatment Plant.—The water derived from Mamaroneck River flows by gravity from the old dam just west of the new filter plant, through a 30-in. cast iron main to the electrically driven low lift centrifugal pumps, the battery of low lift pumps consisting of three units, each capable of pumping 3 M.G.D. against a 25-ft. head.

On its way to the low lift pump the water passes the chemical house wherein provision is made for chlorination

either as super or prechlorination to the raw water or for chlorination of the final effluent. Likewise means have been provided for the use of practically any form of known coagulant to raw water, likewise for any alkaline corrective treatment that may be required by either the raw or filtered water. This equipment in its entirety is within a chemical house provided with an hydraulic lift, with an upper chamber of large storage capacity, and with floor hoppers of the closed welded metal type for gravity flow to the dry feed chemical machines located directly underneath. All apparatus is in duplicate. Dry feed machines are provided with dissolving hopper and eductors to convey the chemical solution against head to the points of application. Also for emergency use one portable electrical dry feed machine is provided and available for application of chemicals at any point in the process of water treatment that may be desired.

Passing from the low lift pump the water is forced into either the mixing chamber, primary sedimentation basin of Dorr Clarifier type, or secondary sedimentation basins. The mixing chambers are two concrete tanks placed within the filter building in line with the filters. Each mixer is supplied by an underflow baffle from a central entrance chamber, provided with a hydraulic automatic control valve that maintains a fixed elevation of water in these mixers. Each mixer is provided with a 12-ft. diameter concrete throat in its center wherein revolves a motor-driven Dorr impellor agitator. The water previously treated with coagulant enters at bottom of the mixers, is agitated vertically by the impellor, as it crosses and finally reaches the opposite side of each mixer where it decants through an upper level port either into the Dorr clarifier or the secondary subsiding basins. These mixers are designed for an ultimate retention of 20 minutes. This apparatus is efficient; its action is beneficial in formation of mass floc; compact, operating without any appreciable loss of head; all of which are valuable and suitable adjuncts in the treatment of this water.

For primary subsidence a 60-ft. rectangular Dorr clarifier with capacity equal to one hour retention is utilized. Limitation of available space restricted the total settling period to three hours; therefore, a basin of this type (with its self-cleaning feature without interruption to service) is peculiarly applicable.

Sludge from the clarifier can flow by gravity to the sludge filters or by a sludge pump be recirculated to the mixer where a proportioning device feeds part or all of this sludge either into the mixing chambers or the sewer.

Recirculation of certain types of sludge has demonstrated that this process has merit. Its action induces mass floc formation that settles out quickly with only moderate increases in the chemical doses.

For secondary subsidence there are two covered concrete tanks, having a combined capacity equivalent to two hours, which used in conjunction with the Dorr basin furnishes a combined retention period, after mixing, of three hours, all that could be provided within the limited area available.

The filters consist of four filter units each of 1¼ M.G.D. capacity; with tank construction of reinforced concrete on rock foundation. Filter units have central flume with cast iron circular wash water collecting gutters, 27-in. depth of filtering sands superimposed on 16 in. of graded gravel.

The under drain system in each filter unit consists of two cast iron elliptical manifolds with brass laterals 2 in. in diameter and umbrella type strainers equipped with air trap tubes. The beds are washed by utilization of the air and water wash. Before applying wash water the bed as a preliminary to the washing process, is drained to 8 in. below the gutter lip, then agitated with air for a period of about three minutes, following which the wash water at a 15-in. vertical rise per minute is applied. Each filter is equipped with an effluent controller arranged to slow down automatically at times of high water in the clear water basin. Marble operating tables are provided for each unit equipped with indicating loss of head gauge and control valves for operation of hydraulic valves and sluice gates.

The effluent from each filter passes into a collecting flume directly under the pipe gallery, from which it rises through an illuminated sight or detector well to the influent flume of the aerator. This sight well is 4 in. by 4 in. white tile lined bottom and sides. The depth of filtered water visible is 10 ft. and the illuminant a high power daylight electric lamp. This detector sight well is extremely delicate in operation; it shows the slightest passing of color, turbidity or hydrate. Its particular merit is that it has all hands busy correcting any operating trouble before it becomes serious enough to impair the quality of water delivered to the distribution system.

The filtered effluent then passes over an open non-freezing type riffle plate aerator, thence into the clear water basin from which by either of three high lift DeLaval electric driven centrifugal pumps (each having a total capacity of 8 M.G.D. against 300 ft. head), the water is pumped into the distribution system, now provided with a 600,000-gal. storage elevated tank reservoir for smoothing out peak demands and as a stand-by to the distribution system.

Waste water from the filters and the settling basins is passed to a sludge filter to prevent fouling of the stream below the plant by sludge deposits.

For reliability and economy of operation a Diesel engine driven generating plant was installed in duplicate.

Operation.—The new filtration plant was started during the last week of February, 1929, operating with sulphate of alumina as the coagulant preceded by chlorination. Prechlorination in conjunction with this coagulant was essential at all times to insure complete color removal.

The optimum coagulation was found to be variable but always within a narrow pH range, necessitating daily laboratory determination for guidance of plant operation.

Vigilant care was required to prevent over or under dosing, both resulting in unsatisfactory or pin point floc formation, colloidal in character. Excellent heavy floc formation was at all times obtainable, using soda ash or hydrated lime, previous to the application of sulphate of alumina but their use intensified and set the color. Correction for aggressiveness was possible only after filtration. Applying corrective alkaline chemicals at any point before filtration would result in intensified and fixed color.

Aeration is of material benefit in removal of taste, odor and CO_2 with the consequent saving in amount of corrective chemical treatment after filtration.

With warm weather during the 1929 season came the drought. Low stream flow and algae troubles with intensified taste and odor in the raw water caused filter operating difficulties.

Control of algae by copper sulphate treatment of the stream, likewise the continuous feeding of this chemical mixed with granulated sulphate of alumina through the dry feed machines proved ineffective. The algae was found to be resistant to any control by use of copper sulphate. Instead of abating it increased. Slime algae grew on the sand in the filters, causing sand shrinkage, cracking, mud balls and short irregular filter runs. Super prechlorination with potassium permanganate treatment controlled the algae growth, cleaned up the filter sand, stopped the shrinkage and cracking and eliminated the taste and odor.

The chlorine absorption of the water was both variable and quite high. This was successfully controlled by operating on a fixed residual chlorine of 0.5 p.p.m. in the Dorr effluent. This provided an effluent free from gas formation and with safe bacterial counts. Summer was well advanced, however, before we could secure more than the necessary residual chlorine in the filter effluent; the heavy chlorine dose was consumed by oxidation in the sand beds.

When the residual chlorine began to increase in the filter effluent, the trouble was over, the beds were free of organic matter and the chlorine dose was reduced accordingly.

Potassium permanganate was applied by mixing it with the sulphate of alumina, apportioning a definite amount and mixing it with each bag of coagulant before it was dumped into the hopper of the dry chemical feeders.

The dose of potassium permanganate to start with was 0.2 p.p.m., increasing in amount with the intensity of taste and odor until during the peak the dose

reached a maximum of 0.45 p.p.m. for a short period, this dosage being reduced as the taste and odor in the raw water abated.

Plant treatment as outlined continued during and following the dry period, delivering a satisfactory effluent but accompanied by rigorous, vigilant watching and correcting of chemical dosage until January of 1930, when the river froze over and the raw water temperature dropped close to the freezing point. With this drop in temperature it became impossible to coagulate this water except by use of hydrated lime applied previous to the sulphate of alumina. Excellent floc formation was obtained but the filtered effluent had a fixed yellow stain and lime started to deposit on the sand of the filter beds.

At this time and under such conditions a plant scale experiment was made using ferric iron as a coagulant. The results were so satisfactory and far reaching in their benefits to the plant as a whole, with incident ease of control and operation that what was started only as an experiment has continued as routine plant operation.

Use of Ferric Iron. — Plant control, using ferric iron coagulant, is based upon two simple tests made by the filter attendant at the mixing chamber:

1. Observation of the character of the floc formed, using a floc detector. The operator's eye is quickly trained to tell the difference between good and improper floc formation. If there is any question as to whether the water has secured proper treatment filtering 50 to 100 c.c. through filter paper and noting color of resulting effluent is a quick and ready checkup. The sampling point for these determinations is at the effluent side of the mixing chamber, or 20 min. after the chemical dosage.

2. Determination of residual chlorine in water sampled from the influent side of the mixer where approximately 0.2 p.p.m. of residual chlorine, or higher, is maintained as may be required for control of algae growths, tastes or odors.

This last test is within a 5-min. period following application of the chemicals. It insures sufficient chlorine to react with all the iron, thereby preventing free iron from passing into the basins and also compensates for the variation in chlorine absorption of the raw water.

In so far as we have been able to determine from the action so far encountered on this water the best coagulating results are obtained by:

A—Preparation of the coagulant is made with close regulation of chlorine in an amount not to exceed by more than 10 per cent the theoretical requirements.

B—Prechlorination of raw water to an amount sufficient to secure a residual chlorine of approximately 0.2 p.p.m.

C—The application of chlorine for prechlorination is made separate from the application of the chlorine for the purpose of preparing the coagulant.

D—The coagulant is applied to prechlorinated water.

E—Anhydrous ammonia is applied to remove and prevent any chlorinous taste or odor. Anhydrous ammonia is applied to the filter effluent.

Under such control the operators have and are maintaining a sparkling, brilliant, plant effluent free from any taste or odor, with considerable ease of operation, especially so when contrasted with the use of sulphate of alumina as the coagulant on this plant.

Action of these two coagulants, on this particular water, compares as follows:

Comparison of the Action of the Two Coagulants

Sulphate of Alumina Coagulant	Ferric Iron Coagulant
Low temperature of water prevented floc formation, unless hydrated lime is used, resulting in set of yellow color in effluent and lime deposits on the sand beds.	Temperature of the water has no effect on floc formation even under the coldest condition of water with stream frozen over.
Good floc formation is only with a narrow pH Range.	During period of operation Raw Water has varied from a pH of 6.0 to 7.6 without any apparent action detrimental to or in favor of floc formation.
Over and under-dosing causes pin point floc formation of colloidal character that would not settle out in the available settling period.	Under-dosing will not throw down all color, and effluent will show stain and lack of brilliancy.
Color and hydrate pass filter resulting in clouded effluent.	Over-dosing has no deleterious action other than extravagant use of chemicals causing a heavier and more rapidly settling floc than is required, it shortens filter runs without impairment of quality or brilliancy of filter effluent.
The floc formed is very light and buoyant. The retention period available is not sufficient to cause efficient settling. Floc passes over on and blankets the filter beds causing short runs. Floc on filters so dense that wash water gutters are not visible through 3 feet of water.	Floc formed is heavy, settling quickly in the available basins.
Slightest variation in water level in settling basins stirred them up and brought heavy floc over on filter beds.	Small amounts of floc come over on filter beds, runs are lengthened and water while flocked sufficiently to produce brilliant effluent is clear so that not only the wash water gutters but the surface of the sand bed is clearly visible.
Three (3) hours settling period followed by filtration period: successfully handles flood conditions but due to characteristics of floc formation the filters carry a heavy burden that materially shortens the run period.	Variation in water level in settling basins as great as three (3) feet does not stir them up or cause heavy floc to come upon the filters.
The light feathery floc of this coagulant formed a dense mat upon the sand beds, causing trouble from air binding of filters—shortened run. Irregularity of flow caused released the accumulated air entrained in the gravel and lower sand layer, which bursting up through the beds destroyed their efficiency and allowed color and hydrate to pass through.	Turbidity increases weight of floc and rate of subsidence. Four floods have so far occurred, since use of ferric iron coagulant. The character of effluents from the Dorr basin have remained clear. So far flood turbidity has been controlled within a thirty (30) minutes settling period without any material increase of filter load.
Impossible to retard flow or stop filter, without passing color and hydrate. When necessary filters had to be taken completely out of service, washed and filtered to waste for thirty (30) minutes before effluent was safe to turn into filtered water basin.	This trouble was eliminated within forty-eight (48) hours following use of this coagulant at the plant.
With alum coagulant, despite the self-cleaning apparatus of the Dorr, due to lightness of floc and its accompanying slow settling characteristic, it has been necessary to clean the secondary settling basins monthly, due to the accumulation, during this period of time, of about an eight (8) ft. depth of sludge.	Use of Ferric Iron corrected this difficulty at once—Filters can now be shut down at any part of the run without damage from release of entrained air and started up without washing or filtering to waste delivering a brilliant water at all times. Since use of this coaguant we can operate intermittently by closing entire plant down from midnight to 4 a. m. during which period water is pumped from clear water basin storage.
Sand grains are coated with gelatinous films of alumina hydrate with all its accompanying filter operating troubles.	With use of ferric iron the same procedure of cleaning secondary settling basins each month has been adhered to but the accumulated sludge is only two (2) feet in depth. This is due to increased settling action in the Dorr occasioned by the heavier floc formation of the ferric iron.
	Sand is free from all gelatinous film and as clean as fresh new sand.

Acknowledgment.—The foregoing is an abstract of a paper presented at the St. Louis Convention of the American Water Works Association.

Milwaukee, Wis., Has No "Free Water"

The following note is extracted from the 1929 report of the Common Council of Milwaukee, Wis., on the municipal government and activities of the city:

The schedule of water rates first placed in effect in 1921 had been formally filed with the railroad commission on July 20, 1926, to be effective 10 days after this date, as provided by law, and on Dec. 9 of the same year, following a hearing regarding the reasonableness of the rates, the commission issued an order approving them. Several large water consumers appealed to the supreme court from a judgment rendered by the circuit court for Dane county which sustained the order of the railroad commission approving of the water rate. In a decision rendered by the supreme court on Oct. 8, 1929, the action of the railroad commission approving the following rates was affirmed.

For water furnished inside of the city a uniform rate of 7 ct. per 100 cu. ft., equal to 9½ ct. per 1,000 gal., and for water furnished outside of the city, 10 ct. per 100 cu. ft., equal to 13⅓ ct. per 1,000 gal. In addition to the charges for water consumed, there is a "service charge" of $2 per annum, assessed against every meter, regardless of the size of meter, service pipe, or quantity of water consumed. Automatic sprinklers are charged $25 annually for 4-in. connections and $50 for 6-in. connections. No free water is furnished to anyone.

Residual Chlorine Control

Experiences at Little Falls, N. J., and Rahway, N. J., with New Automatic Recorder and Controller

By J. WESTFORD CUTLER and FRANK W. GREEN

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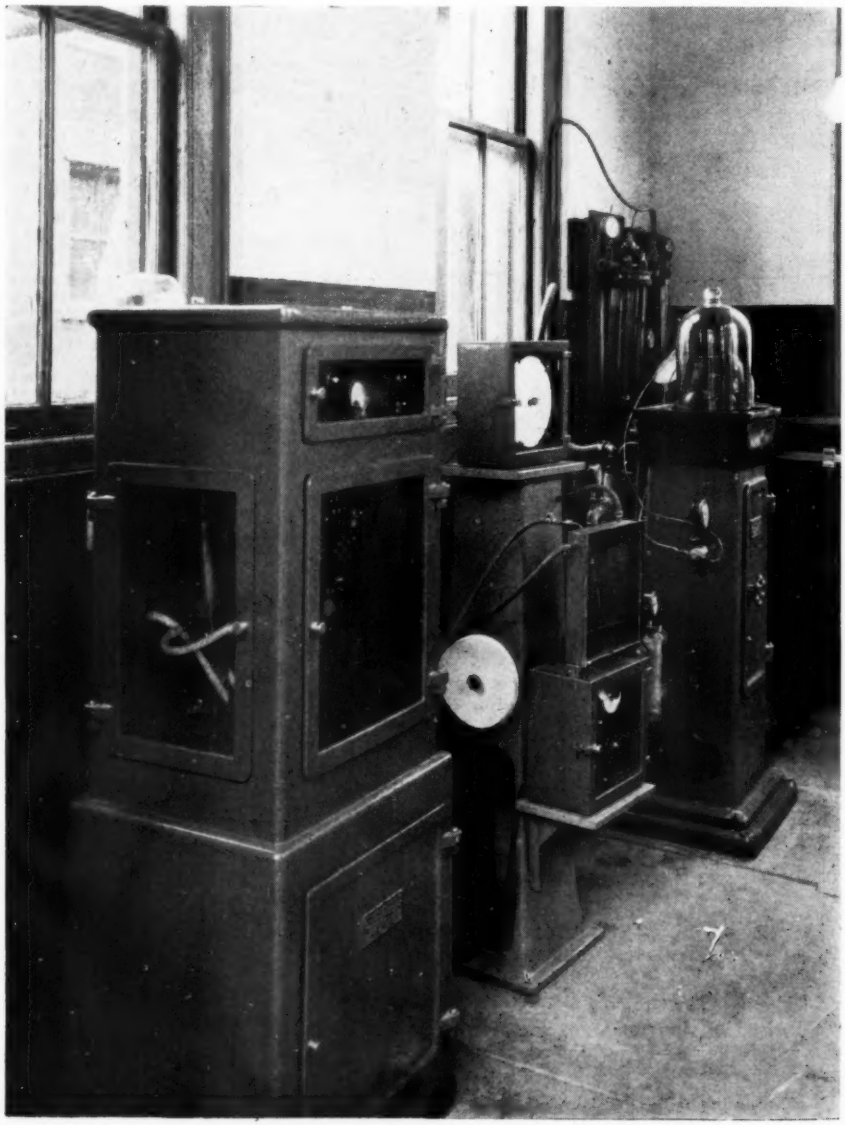
THE art of chlorination has become well established in the minds of the water works profession. Chlorination was started with the use of very crude equipment. Step by step this equipment was perfected.

When chlorine is added to water a certain amount is absorbed by substances in the water in addition to that required for the killing of bacteria. If more chlorine has been added than is required for such absorption there will be an excess which is commonly termed "residual chlorine." This residual is used as a safety factor, and because this excess is easily measured by the use of orthotolidin, it has been generally accepted as a standard control in water purification work. The difference between chlorine applied and chlorine residual represents the chlorine demand of the water and this chlorine demand varies over wide limits. In the light of these facts, a desire arose for a perfect control system whereby chlorination was accomplished not only automatically in proportion to flow of water, but would stand the test of legal cross questioning. It is apparent that such a control equipment would be a most useful tool in water works operation. Heretofore automatic equipment, although far better than manual, has not been the perfect control system. All variables involved in water treatment were not covered. Automatic equipment would compensate for changes in flow or pumpage, but not for any variation in the chlorine consumption of the water itself. It was necessary for the chemist to detect this change in chlorine demand by tests, and then manually adjust the chlorine dosage.

Few plants are able to use a constant chlorine dose, day in and day out, over long periods of time, and obtain a constant residual, because of the changes in flow and in demand. In order to be sure of a residual at all times various means are resorted to, such as carrying an overdose of chlorine; maintaining very careful supervision with frequent tests; or, in an increasing number of cases, applying automatic equipment to care for variations in flow. Where conditions are unusually erratic all three of these means are used. With all these precautions demand may still not be properly taken care of and there is no assurance on the part of those responsible for the character of the water delivered to the public that a residual has been maintained in every gallon of water delivered by their system. To overcome these difficulties the functions of the chlorine control equipment are: (1) It must automatically care for flow changes in the water treated. (2) It must adjust automatically the dosage for chlorine demand. (3) It must provide a legal 24-hour record. How these functions are performed in the new atuomatic residual recorder and controller will be described.

The New Automatic Recorder and Controller.—The world was benefitted when the great tool known as the photo-electric cell was perfected. Vastly complicated mechanical devices have been developed in and around these light sensitive cells, such as talking moving pictures, television, automatic counters, and high speed sorting machines for color, size or shape. These are only a few of the vast quantity of devices wherein the photo-electric cell is fundamental. These cells are obtainable in all sizes, shapes and kinds and a large majority are designed for special purposes wherein particular qualities are built into the cell so that it may perform a particular duty.

The cell which is the backbone of the Wallace & Tiernan residual control apparatus is of still another category and was selected for its ability to pass



Residual Chlorine Control, Little Falls, N. J.

a sufficient amount of current to operate the equipment in its circuit without additional amplification. The equipment is essentially simple, both in design and in operation. The electrical units and electrical circuits are not complicated. It has been found most practical to use an intermittent system wherein a record is made, chlorine dosage adjusted, and everything turned off for a period of time before a repetition of this cycle. The adjusting of the length of time between cycles is at the discretion of the operator.

There are four principal parts to one cycle of the apparatus. An electric motor starts and runs the machine through these four parts in their proper order and stops for the desired time interval. They may be listed as follows:

1. A light source must provide illumination in a manner which enables the photo-electric cell to measure and compare the color of the solution.

2. A mechanical relation must be set up which corresponds with this measurement.

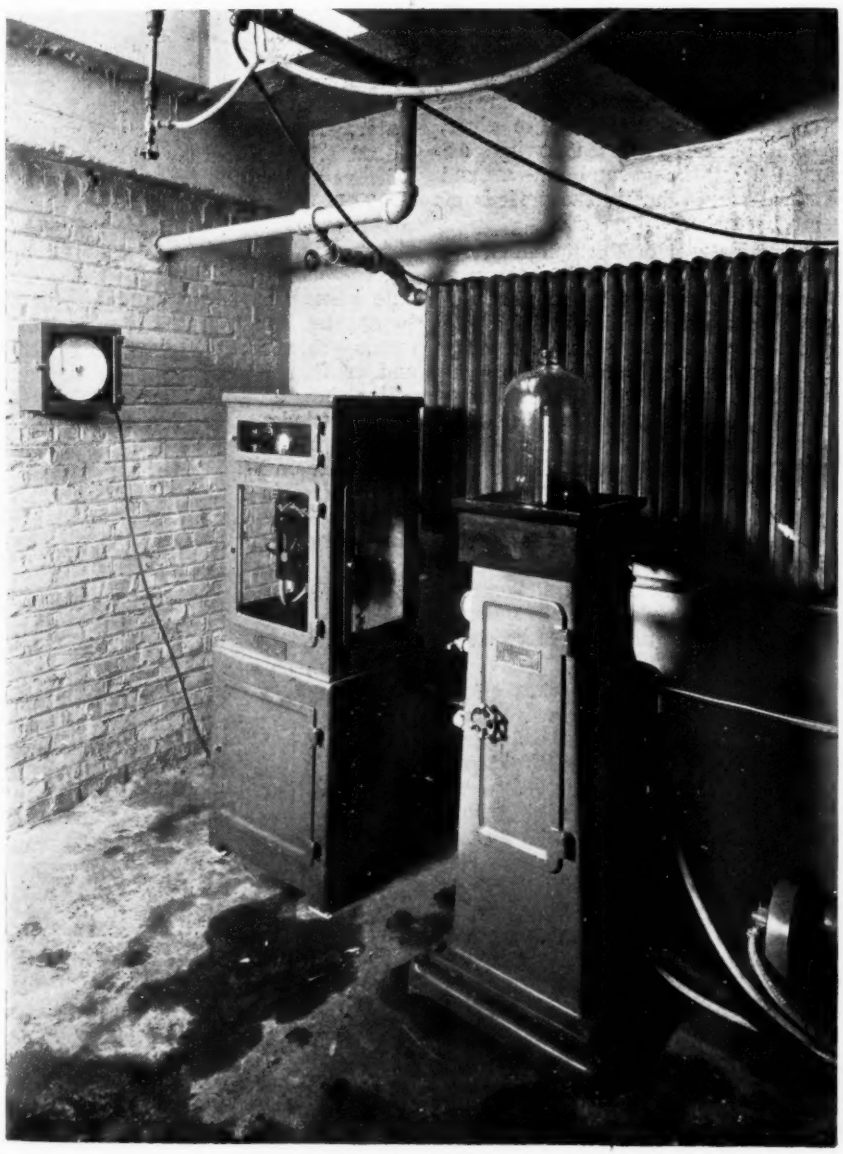
3. The above mechanical relation must operate a pen on a chart and adjust the chlorinator.

4. The apparatus must automatically obtain for itself a new and fresh sample of treated water and add the proper amount of orthotolidin at the proper point.

In order that these various departments perform their action in the proper order, the equipment is arranged to operate from two shafts, geared to each other with an 8 to 1 ratio. The slowest of these shafts makes one revolution for a complete cycle.

Operating Results.—The development of this machine has been the work of something over four years, during the course of which four models have been built and operated.

The first practical installation was made at Little Falls, N. J., in August, 1929, at the plant of the Passaic Consolidated Water Co. This plant has a 75 m.g.d. output wherein a river water is filtered, chlorinated, and pumped to Paterson, Passaic, and several other communities.



Residual Chlorine Control, Rahway, N. J.

At first the installation was made taking a sample of the entire output of the plant and making a record of the variations in residual of the delivered water. Between August and the end of December, 1929, after several minor changes were found necessary, it was sufficiently proved that the apparatus was suitable and safe to attach to a chlorinator and proceed with the original design—that of control of chlorination by residual. Therefore, in January the equipment was moved and attached to an automatic chlorinator. This was to control the chlorination of a certain section of the Little Falls Station. The output from a 63 m.g.d. battery of gravity filters flows by gravity some several hundred feet to the pumping station and in this suction line there are two chlorine applications, the sum of which constitutes chlorination for this section of the system.

First, some 125 lb. of chlorine are added to the water from a series of electrolytic cells and on top of this an auxiliary chlorinator adds a variable amount of chlorine of approximately 50 lb. average as an adjustable trimmer. This adjustable trimmer supply of chlorine is connected to the residual control outfit. The pump discharge returns to a point very near the location of the chlorinators and a sample line is brought over to the residual controller. In this manner there is a lag of 10 minutes between the point of application of chlorine and the supply box at the rear of the residual controller. After correcting a number of minor mechanical difficulties, some of which were due to an unusual current source of 220 volts d.c. for which the machine was not designed, the entire assembly of apparatus functioned satisfactorily.

Manual orthotolidin tests, taken as a check on the apparatus at frequent intervals, showed that the controller was picking up the variations in demand and flow. An 80-lb. chlorine meter on the chlorinator was frequently called upon to change over its entire scale in response to these demand changes.

The 10-minute lag between application and sample, while annoying at times, was found to have no serious effect upon the final result. It was very gratifying to note on several occasions that unexpected changes in output from the chlorine cells were compensated for very promptly by the controller.

Some little difficulty was encountered with the long interval required to develop color in the cold water flowing during the months of January and February, but the use of a stronger concentration of the orthotolidin solution and slightly warming the water corrected this condition without impairing the quality of the results obtained.

Careful observations by officials of the Little Falls Plant showed satisfac-

tory control between 0.18 and 0.21 p.pm. At various times the standard glass was changed rendering a different range of control.

Early in April, 1930, another installation was made in a water works of different character—that of the municipal plant at Rahway, N. J. This plant pumps less than 6,000,000 gal. per day and desires to maintain a residual between 0.05 and 0.1 p.p.m. in fear of taste difficulties frequently encountered with high residuals. This installation was made in a 30-ft. run of exposed filter effluent line, running from the filters to a covered clear well. The chlorine was applied at the beginning of this 30-ft. 24-in. line and a sample was taken about 25 ft. beyond the point of application. This was necessary because of a 2-hour detention in the clear well before a sample could be obtained. The velocity in this pipe averages about 2 ft. per second and there seemed to be sufficient mixing for the sample to be a true one at the machine. In order to be certain of time for chlorine absorption a retention of 5 minutes was added to this sample before it entered the machine. Time for development of color was of course allowed in the machine itself. Operating on this short line a very snappy control was obtained and the standard was set for approximately 0.15 p.p.m. in order to control a 0.05 p.p.m. residual after the 2-hour interval. While this installation has not been in use very long the evidence available to date assures its success.

Adaptability of Residual Control System.—The system of residual control is adaptable in many ways other than the two just mentioned. It may be used as a warning of approaching pollution by locating the machine upstream and the chlorinator far enough downstream to protect the water supply when the controller indicates the need of increased chlorination to protect the water. The design is such that even miles may intervene between controller and chlorinator. For Great Lakes water supplies this feature offers innumerable arrangements to indicate points of sudden high demand and protect the consumer. Large savings in chlorine will often result and a great deal of responsibility from a legal point of view can be automatically taken care of. It may even be contended that the record offered by this equipment, and the legal significance thereof, will be its greatest advantage to water works users.

Not only, however, is the machine adaptable to chlorination. Experiments are already well under way for the application of this machine to hydrogen ion control. There is no question, but that it could be used in the regulation of turbidity or natural color in the water, and several cases have been brought to the attention of the developers for industrial uses.

The art of chlorination has again progressed. Another great tool has been added to the list of photo-electric devices. Another advance has been made in the protection of public health. As a process it is in a well developed stage. As a mechanical device, it is functioning well and will continually be improved as experience indicates.

Acknowledgment.—The foregoing is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

Odor and Taste Control at Charleston, W. Va.

By LAWSON HAYNES
Filtration Superintendent

During the winter months of 1929 and 1930 phenol wastes in Elk River caused obnoxious tastes and odors in the water supply of the Charleston Plant.

This condition existed during severe cold periods, when the temperature of the river water was near the freezing point, and also during the period of thaw following a severe cold spell. Conditions were at their worst after a protracted thaw when large quantities of water were coming from the water shed, carrying into the river, oils and phenol wastes that had accumulated on the ground and around industrial plants during the periods of freezing weather.

Use of Potassium Permanganate.—The first treatment applied to the raw water was 2 per cent solution of Potassium Permanganate which was fed into the discharge from the low lift pump and before the water entered the sedimentation basin. Potassium Permanganate was first applied at the rate equal to .12 p.p.m. being increased later to a maximum of .18 p.p.m. This treatment gave a slight color to the water entering the sedimentation basin but the color soon disappeared from the settled water. For a slight phenol taste this treatment seemed successful, but when a larger amount of phenol was present we were not able to combat it satisfactorily.

We are unable to state what effect larger dosage of potassium permanganate would have had on the finished water as representatives of the State Department of Health requested us to try the anhydrous ammonia treatment as they regarded this treatment as the one that would be most successful.

Anhydrous Ammonia and Potash.—With permanganate applied in the pump discharge anhydrous ammonia was introduced into the settled water just prior to filtration. This treatment was successful in removing phenol tastes but no chlorine residual could be detected in the clear well due to the reaction of the ammonia on the chlorine. However, laboratory experiments showed that a sample of water from the clear well, after standing for about one hour, had a chlorine residual. No tests were made at the time to determine chlorine residual in the distribution system. This latter test should have been made but conditions obtaining at the time experiments were being made with the treatment would not permit of same. During the test above mentioned we applied permanganate at the rate of .18 p.p.m. and anhydrous ammonia at the rate of .12 p.p.m.

Ammonia Successful.—The next experiment in the treatment was to eliminate the potassium permanganate and apply ammonia into the raw water intake to the basin. The point of application was such as to allow a period of contact of 1½ minutes before the raw water entered the sedimentation basin. A chlorinator was installed to chlorinate the water at the point of entry to the basin. Ammonia at the rate of .12 p.pm. was first applied and increased later to .18 p.p.m. and sufficient chlorine was applied to maintain a residual of from .2 to .3 p.p.m. at the influent end of the sedimentation basin.

This method of treatment was started at 3:00 p. m. on Feb. 1, 1930. At that time a very decided phenol taste existed in the raw and also in the finished water. Numerous complaints were received at the filtration plant and local office regarding the taste of the water. By 7:00 p. m. that same day no tastes could be noticed in the finished water at our plant and by the following morning complaints had ceased. Since that date when phenol compounds are liable to appear in the raw water the ammonia—chlorine treatment is started and continued until tests on the raw water show no phenol present.

Acknowledgment.—The foregoing is a paper presented at the 5th annual conference on Water Purification of the West Virginia State Health Department and the Engineering School of West Virginia University.

Texas Sanitarians' Short School.—The 8th Texas Sanitarians' Short School will be held at Amarillo, Aug. 26, 27 and 28, with Herring Hotel as headquarters. Local city and county officials are expected to arrange for sending representatives as usual to receive the benefit of the special training on water supply protection and purification, sewage disposal, milk sanitation, food protection, mosquito control, swimming pool sanitation, camp sanitation, general nuisances and menaces to health. The school is under the joint auspices of Texas State Department of Health, Texas Association of Sanitarians, and City of Amarillo. Dr. H. H. Latson, city health officer, is general chairman; and Jack Wyatt, director of the school, Amarillo; Dr. J. C. Anderson, state health officer, Austin; Dr. H. K. Read, president, Texas Association of Sanitarians, Houston.

SEWAGE DISPOSAL WORKS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. DOWNES, Associate Editor
Supervising Engineer, the Plainfield and Dunellen, N. J., Sewage Disposal Works

Two Questions Answered

What is the best material for large trunk sewer lines: Concrete poured in place, or precast concrete lined either with tile or brick, and if the latter, should the lining be complete or only in the lower half of the sewer?

This is a big order for a column of this kind since each case should be decided by competent engineers on its own merits. The question probably arises from the publicity given some time ago to the failure of concrete sewer outfalls in Los Angeles, Calif.

The writer's experience would indicate that concrete can be made to stand almost any condition that would be encountered in an outfall sewer if sufficient care be given to the preparation of the concrete and especially to its placing. There are exceptions in the case of particular trade wastes.

Aside from the use of the best of materials and the use of the proper proportion of water, of equal importance with these considerations is the rodding in of the mixture so as to eliminate all air spaces and make the most dense concrete possible. A dense, smooth original surface must be obtained by proper care of forms and by "cutting in" next to the form with a broad thin blade. Patched or resurfaced concrete will not stand the gaff.

Failure of concrete sewers, such as that at Los Angeles, is usually associated with high sulphate content of the sewage. As soon as the sewage becomes at all stale, bacterial action starts in with the production of large quantities of hydrogen sulphide (which is potentially sulphuric acid so far as its effects are concerned). This condition is particularly apt to give trouble wherever sea water may gain access to the sewer lines.

The disintegration of concrete under such conditions sets in at, or above, the flow-line; not beneath the water. There are several reasons for this: the liquid forms a protective coating on the concrete which is absent above the water line, the hydrogen sulphide requires oxygen to get in its worst work; this oxygen is present in the moist air above the liquid, but not in the stale sewage itself, and finally the alternate wetting and drying of the upper part of the sewer permits concentration of the acid which could not occur in the liquid itself.

The above explanation will answer the last part of the question, "Should tile lining be complete or only in the lower half of the sewer?" If one were to half-line the sewer he should line the top, not the bottom.

If conditions are such that a lining seems to be required, particular attention should be given to the quality of the mortar used in the joints. Ordinary mortar is very absorptive and placed in thin layers between tiles presents optimum conditions for disintegration by hydrogen sulphide.

Where the sulphate content of the sewage is such as to indicate possible trouble from disintegration by hydrogen sulphide, application of liquid chlorine to the sewage to prevent formation of this troublesome gas would be in order.

In considering the relative economy of tile lining of the upper half of the sewer as compared with that of treatment of the sewage with chlorine, it should be remembered that the chances are that the sewage would have to be chlorinated for odor control anyway and that prechlorination at some point up the outfall sewer would kill both birds with one stone.

We have two circular digestion tanks with provision for heating, circulating and adjusting the reaction of the sludge also for collecting the gas under safety covers. After filling the first tank and working the reaction up to the proper point and the temperature up to 77° F. we were getting 3,500 cu. ft. of gas per day. Then we let the first tank stand, while we started filling the second, and in a very few days the gas flow from the first tank stopped. Do you think that the gas is getting away somewhere?

No the gas is not getting away. You simply are not getting any gas because, as you say, you are "letting the tank stand." In other words, you are not adding any fuel to the process and the process stops when the available supply is exhausted. In order to secure a steady flow of gas you must add a steady supply of fuel just as you must supply fuel to a fire to keep it burning.

Now that the gas has stopped flowing, if you begin making regular additions of green sludge daily the gas will soon begin to come off again, but not in full flow for about two weeks, at which time there will be a very violent ebullition of gas. After a few days this will quiet down and you will again have a steady dependable flow as long as you supply a steady dependable quantity of fuel, and keep the temperature up. You may have to readjust the reaction during the interim, but this will require little attention once you get the tank back in its stride as to gas production and maintain a steady food supply.

Use of Sewage Gases by Public Utilities

The 1930 meeting of the Pennsylvania Sewage Works Association was held at State College, Pennsylvania, on June 26 and 27.

Accommodations and arrangements for the meeting were most excellent and a great deal of forethought and good judgment were shown in preparing the program, with the result that there was no crowding of formal papers and no dull moments when the program dragged. This is a happy balance which it is easier to talk about than to attain.

One was much impressed with the hearty participation of the operators in the program, which while being the aim of these meetings is also difficult of attainment.

During the formal meeting the operation of the various plant units was discussed by picked leaders and the discussion was carried on freely during an evening social session featured by the reading of numerous questions which had been asked and which were referred to various persons by the chairman for opening of the discussions.

The impression left by this meeting was a feeling of satisfaction with the progress that is being made in the art of sewage disposal and in the development and spread of information. The grasp which the men in the field showed of the latest developments offered by scientific research is both surprising and gratifying.

The outstanding paper of the ses-

sions, one which provided much new information, was one by Mr. W. H. Fulweiler, of the United Gas Improvement Co., on "Gas Collection at Sewage Treatment Works."

Mr. Fulweiler is not primarily interested in the sewage field, but was called upon by the United Gas Improvement Co. to investigate reports of German origin on the possibility of the recovery and sale of sewage gases to public utilities at a profit.

While his final conclusions were that the sewage gas is insufficient in quantity and unsuited by its characteristics to be interesting to the utilities and that the profits reported in Germany could not be other than a matter of bookkeeping between different municipal departments, these conclusions were drawn only after a very thorough and exhaustive study of the matter, which brought to light several facts which seem to have heretofore escaped the attention of men in the sewage field.

Comparing an average of analyses of sewer gases from different sources with the analysis of various gases commonly used by utility companies he showed that the sewer gas is a slow moving and sluggishly burning gas because of its comparatively high specific gravity. The high specific gravity is the result of the entire absence of hydrogen which forms from 27 per cent to 50 per cent of other gases commonly so used.

In burning gas it is caused to issue from the burner at a rate sufficiently in excess of the speed of flame propagation so that the flame will continue to burn at the tip of the burner and not flash back.

Since the rate of flame propagation of hydrogen is 16 ft. per second and that of methane (the principal constituent of sewer gas) is but 3.9 ft. per second, the ordinary gas burner is not at all suitable for burning sewer gas because the flame would tend to blow away from the burner.

Many of us who have watched experiments with the burning of sewage gas, will readily recognize Mr. Fulweiler's scientific explanation of the peculiarities which we have observed in the flame, and will set about looking for more suitable types of burners than now used. As he pointed out, however, it would not pay the utilities to go to the cost of altering equipment, particularly as the available quantity of sewage gas could never exceed about 1 per cent of the domestic requirements of our communities.

The high specific gravity of the sewer gas would greatly complicate its distribution. As an apt illustration it was pointed out that to force 20,000 cu. ft. of gas per hour through five miles of 4-in. main would require 40 hp. in the case of sewer gas as against 24 hp. in the case of coke oven gas.

While the sewer gas would be valuable as an enriching agent because its heating value is comparatively high, 750 B.t.u. against 550 for manufactured gas, it was pointed out the equipment required and cost of transporting the gas would render the application of this idea impractical in most cases.

Not satisfied with presenting the negative result of his study from the point of view of the utilities, the author took up the possibilities of the use of the gas about the sewage plant as for heating sludge and indicated that the gas does pay a profit when so used, because by making possible the use of smaller tanks it saves on capital costs and consequently on interest charges.

The paper contains several interesting tables and charts on comparative analyses, gas production, gas consumption, etc.

Sewage Disposal Plant Operation at Milwaukee, Wis.

The sales of a fertilizer called Milorganite during 1929 paid about 68 per cent of the cost of operation of the sewage disposal plant of Milwaukee, Wis., according to the 1929 report of the Common Council on Municipal Government and Activities of the city.

Operation and maintenance of the Milwaukee metropolitan sewage system, including both collection and disposal of sewage, involved a net cost of only 66½ ct. per capita for the entire year of 1929. This does not include capital charges. A vast reduction in the expense of the system has been effected by the sale of fertilizer called Milorganite which is manufactured from the suspended solids removed from the sewage. The plant produced 34,933 tons of Milorganite, almost 100 tons a day, and shipped 31,600 tons, for which an average price of over $20 a ton was received. The demand for fertilizer exceeds the Milwaukee output and is expected to continue to do so for many years.

About 70 per cent of the output is shipped to fertilizer manufacturers who blend it with other ingredients such as phosphates and potash and sell this product for use mostly in the states that grow cotton and tobacco. The remaining 30 per cent is sold for use directly without the admixture of any other material. This unmixed Milorganite is especially valuable for the growing of fine lawns and for general garden use. Most of this part of the output goes to golf courses, park boards, and other places where fine lawns are maintained. A considerable amount is sold in 100 lb. bags to the gardeners of Milwaukee and the surrounding suburbs. These local sales in 1929 brought a return of approximately $10,000. The retail sale price is $1.50 per 100 lb. bag.

The plant treated from 85,000,000 to 1,000,000,000 gal. of sewage per 24 hours. During each day there is a peak load on the plant which amounts to from 130 to 140 million gallons in 24 hours. The total time of by-passing due to storms was 7.8 per cent of the total number of hours in the year. In other words, 92.2 per cent of all the sanitary sewage brought to the disposal plant during the year was purified, the balance being taken care of by dilution in the rivers and lake.

The cost of the plant operation only, not including any capital charges nor any part of the operation of the intercepting sewer system, in the city and the metropolitan district, is approximately $950,000 annually. At the present rate of production and the present price, the sale of the Milorganite returns about 68 per cent of this amount. The profits realized last year totaled about $630,000.

Tentative plans were made by the chief engineer for additions to the plant which will provide capacity for sewage from the city and suburbs up to 1950. There will be an addition to the dryer house the size of the present building, and three new dryers will be installed.

At the beginning of 1929 an elaborate cost keeping system, which makes it possible to determine accurately the cost of every phase of plant operation, was put into effect.

Introducing chlorine gas into the dryer discharge again proved a very successful method of eliminating the odor nuisance. Very few complaints on this score were received in the course of the year. While the chlorine treatment was originally considered only a temporary expedient, and other methods were carefully investigated, it was found that chlorine was superior in its effect and lower in its operating costs. About 50 tons of chlorine were used during 1929 at a cost of $3 a 100 lbs.

Special Truck Aids Meter Changes in St. Louis

Special trucks for handling water meters are in use in St. Louis, Mo. The special body, which is mounted on a Ford 1½-ton chassis, carries three transverse frames made of 3-in. channels. The frames carry a 5-in. longitudinal I-beam, arranged so that it may be pulled out to project 3 ft. beyond the rear of the body or pushed forward to extend over the roof of the cab. A trolley runs the full length of the beam on the lower flange, and stops are provided at each end. The trucks are useful in replacing large meters set at the curb. Four men were formerly required for this operation, which is now handled easily by a crew of two. Large hydrants and valves are also handled by the trucks.

The trucks are equipped with side lockers and a front locker just back of the cab. The lockers are provided with receptacles for storage of tools and supplies.

Taste and Odor Removed by Activated Carbon

Results of Experimental Work Conducted in 1929 on River Water Containing Objectionable Odors

By GEORGE D. NORCOM and R. I. DODD

Respectively Sanitary Engineer and Chemist, Federal Water Service Corporation, New York, N. Y.

DURING the past two years a considerable amount of attention has been directed to the use of activated carbon for the removal of odor and taste from water supplies. The experimental work which has come to our attention has dealt particularly with the removal of residual chlorine, phenols and chlorophenols. The studies described in this paper have been carried out on river water which had been purified by passage through a rapid sand filter plant. The raw water contained objectionable odors and tastes all of the time and the filtered water contained them to a lesser extent the greater part of the time. These odors and tastes are not due to any one substance but rather to a mixture of substances and at no time could the odor or taste of phenols be specifically detected. The activated carbon has been used in the treatment of this water in such a manner as would be indicated in actual purification practice so that the results should be truly comparable to those which might be secured with a large scale plant.

Description of the Raw Water.—The raw water for the purification plant was secured from the Delaware River at Chester, Pa. The watershed of the Delaware includes a very highly developed industrial territory and here will be found manufacturing plants of almost every type. The wastes from most of these plants eventually reach the river and many of them are of such a nature as to cause objectionable taste and odor in water. The odors most frequently encountered are those caused by the wastes from oil refineries, paper mills, chemical plants and organic matter of domestic origin. With the large dilution afforded by the river and the slow progress of the pollution downstream due to ebb and flow of the tides, the agencies of self purification exert a very beneficial effect, but in spite of this the water at Chester still contains objectionable odors and tastes. Summaries of the intensity of the odors and the predominating types of odor are given in Tables I and II. It will be noted that the intensity is greater during the cold months. Another interesting feature is that a sample of water giving an oily cold odor develops a musty odor when heated. This is probably due to the fact that heating removes certain volatile odors and this permits the detection of other underlying odors of a different character which are classified as "musty."

Preliminary Purification.—In all but one of the experiments the water applied to the carbon filters had been purified by passage through a complete modern rapid sand filter plant employing the following processes in the order named:

1. Pre-chlorination sufficient to produce a residual of about 0.5 ppm. chlorine.
2. Treatment with alum and lime to produce coagulation.
3. Cascade aeration.
4. Sedimentation for about 3 hours.
5. Filtration through sand.
6. Secondary lime treatment for the prevention of corrosion.
7. Secondary chlorination.

The effluent of this plant was free from turbidity at all times and contained a residual chlorine content of 0.2 to 0.4 ppm. The chemical characteristics of this water are indicated by the appended analytical results.

Activated Carbon Experiment, 1929
Sanitary Analyses of Filter Plant Effluent and Effluent Carbon Filter No. 5
Parts per Million

	Filter Effluent Laboratory Tap	Effluent No. 5 Carbon Filter "Darco"
Serial number	S-13983	S-13984
Date of collection	10/16/29	
Date of examination	10/22/29	
Cold odor—20° C.	3 Musty-Earthy	1 Aromatic
Hot odor—90° C.	3 Arom.-Musty	1 Aromatic
Turbidity—silica standard	0.	0.
Color—platinum standard	5.	0.
Oxygen consumed	2.5	2.2
Nitrogen as free ammonia	0.278	0.006
Nitrogen as albuminoid ammonia—total	0.124	0.084
Nitrogen as nitrites	0.015	0.003
Nitrogen as nitrates	0.800	0.800
Chlorine	7.0	10.0
Alkalinity	34.0	37.0
Hardness, by soap method	77.1	80.0
Hydrogen ion concentration, pH	6.6	6.7
Iron	0.10	0.10
Residue on evaporation—total	170.	170.
Mineral residue—total	125.	120.

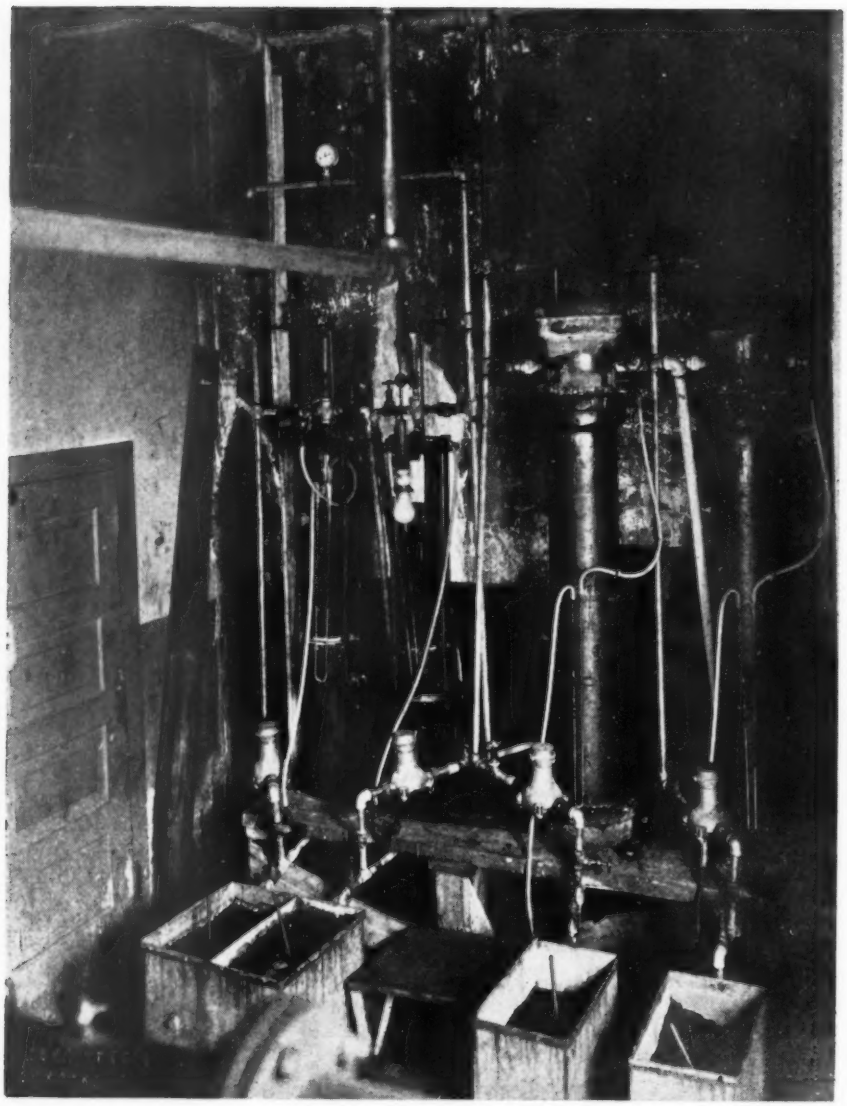
Table III shows the predominating odors in the treated water and the frequency of their occurrence. In Table I the average intensity of the odors is given and the detailed results are graphically depicted on the accompanying chart. The reductions in the intensity of raw water odor effected by the purification plant were 68 per cent for hot odor and 78 per cent for cold odor, based on the averages.

Methods of Odor Determination.—Due to the changing character of the tastes and odors and the varying mixtures of the substances producing them, no simple analytical method has been devised for accurately measuring their quantities. In the absence of a definite parameter it was necessary to fall back on the methods for odors described in Standard Methods of Water Analysis. The limitations of these methods are known to all since they depend on the judgment of the observer and his ability to detect and evaluate odors. Fortunately we were not compelled to rely on one observer alone, many observations were checked by another observer and it was frequently possible to conduct blindfold tests with from 3 to 5 trained observers participating. Doubtless a number of irregularities occurred, but every effort was made to render a fair judgment on all samples examined.

The technique for hot and cold odor was carried out according to Standard Methods but a slightly different system of evaluating the odors was employed. Standard Methods use numbers from 0 to 4 to express a gradual increase of odor and then jumps to 5 for a water whose odor is such as to make it unfit for drinking. We have used the same numerals but have tried to divide the scale of odors from 0 to 5 into even steps.

Observations of hot and cold odor and cold taste were made on all samples of treated water and carbon filter effluents. Observations of taste were not made on the raw river water. In general there is a close relation between odor and taste but our results indicate that the intensity of the taste is usually less than that of the odor. Hot odors are generally of greater intensity than cold odors. For the purpose of judging the efficiency of carbon it is felt that the results for odor are all that is necessary and for this reason, and in order to avoid a multiplicity of data, the results of observations for taste have been omitted.

Description of Experimental Filters.—In the beginning a number of experi-



Experimental Filter Used in Activated Carbon Experiments

ments were run using filters constructed of 2 in. glass tubing. These experiments were sufficiently promising to cause us to repeat them on a larger scale. Pressure filters Nos. 1 and 2 were then constructed of 4 in. glass tubes. The remainder of the filters were constructed of 8 in. cast iron pipe. Each filter was provided with a perforated pipe gird in the bottom, an overflow for wash water, a mercury U tube loss of head gauge and a rate controller. The accompanying photographic illustration and drawing are representative of the installations. All filters were provided with high pressure wash water and all except the glass pressure filters had an auxiliary connection at the bottom for steaming.

The pressure filters contained 4 in. of graded gravel, 2 in. of filter sand and 30 in. of carbon. A 20-mesh copper screen was placed above the carbon. The available pressure was 60 lb./sq. in. The downward flow gravity filters also contained 4 in. gravel, 2 in. sand and 30 in. of carbon, and were provided with copper screens. Later the screens were removed on filters 3, 4, and 6. The total available head on all these

Table I—Intensity of Odors (1929)
(Monthly Averages)

	Raw Water		Plant Treated Water	
	Hot	Cold	Hot	Cold
January	3.5	4.7	1.15	0.73
February	5.0	5.0	1.26	0.96
March	4.3	4.6	1.44	0.90
April	3.7	3.9	0.92	0.63
May	2.9	3.4	1.00	0.54
June	3.0	2.8	1.19	0.65
July	2.8	2.7	0.96	0.39
August	3.8	3.7	1.16	0.26
September	4.0	3.6	1.00	0.73
October	4.0	4.0	1.32	0.64
November	4.8	4.6	1.81	1.08
December	4.8	5.0	1.65	1.55
Average	3.9	3.9	1.24	0.84

filters was about 6 ft. The upward flow filters Nos. 7 and 8 contained 6 in. gravel and 36 in. of carbon and the total available operating head was 2 ft. These filters had no screens. The freeboard between the top of the carbon and the overflow pipe was 24 in. on all filters.

The carbons used had the following characteristics:

Nuchar .....Eff. size 0.51 U.C. 3.72
Darco .....Eff. size 0.55 U.C. 1.8
Minchar: No analysis available.

General Remarks on the Operation of the Experimental Filters.—Above is given analytical results of a sanitary analysis of the effluent of Darco filter No. 5 compared with a similar analysis of the filter plant effluent. It will be noted that the carbon effected a reduction in the nitrogenous matter as shown by the free and albuminoid ammonia. The absorption of carbonaceous organic matter, shown by the oxygen consumed, is not so marked. The various mineral constituents remain unchanged by the carbon.

The removal of residual chlorine was not made the subject of particular study in these experiments. Orthotolidine tests were made occasionally on the various carbon filter effluents and were negative in every case except with the Minchar filters No. 4A and No. 6. The effluents of these filters showed traces of residual chlorine on almost all tests.

Carbon filters were not operated directly on the raw water except for a short time at the beginning of the experiments. It was found that with raw water the carbon bed soon became dirty and clogged due to the presence of turbidity and organic matter. In using the softer activated carbons like Darco and Nuchar on turbid water it is necessary for the water to be completely clarified by preliminary purification. The harder activated carbons, like Minchar can be used to filter tur-

Table II—Raw Water Predominating Odor
Per Cent of Time When Predominating Odor Was:

Month	Oily		Gasoline		Vegetable		Musty		Sewage		Disagreeable		Tarry		Fishy	
	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold
January	25	78	0	18	7	..	19	....	30	....	15	..	4	4	..	..
February	43	100	..	....	..	..	9	....	48	....	....	..	..	..	..	..
March	32	88	8	0	..	..	....	....	64	12	....	..	..	..	..	..
April	4	58	..	19	..	..	11	....	58	19	19	4	..	..	..	..
May	4	58	..	27	..	..	46	7	46	8	....	..	4	..	..	..
June	4	72	..	20	..	..	24	....	64	8	....	..	..	..	8	..
July	4	54	..	11	4	..	42	31	50	4	....	..	..	..	..	..
August	4	96	..	4	..	..	22	....	63	....	....	..	..	..	..	..
September	....	100	..	....	..	..	....	....	100	....	....	..	..	..	..	..
October	19	100	..	....	..	..	7	....	74	....	....	..	..	..	..	..
November	....	100	..	....	..	..	33	....	67	....	....	..	..	..	..	..
December	55	91	..	....	..	..	9	....	36	9	....	..	..	..	..	..

Table III—Plant Treated Water; Predominating Odor of Water
Per Cent of Time When Predominating Odor Was:

Month	Oily		Gasoline		Musty		Sewage		Medicinal		Aromatic		Woody		Vegetable		Misc.		No Odor	
	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold	Hot	Cold
January	7	37	0	4	37	4	15	7	11	0	0	0	11	0	4	0	4	0	11	48
February	13	44	0	0	74	17	0	4	0	0	0	0	0	0	0	0	9	0	4	22
March	0	48	0	0	84	4	0	4	4	0	4	12	0	0	0	0	0	0	8	24
April	4	30	0	4	80	25	0	0	0	0	0	0	0	0	4	0	0	0	12	41
May	4	28	0	0	75	11	3	14	7	0	0	0	0	0	0	0	0	0	11	47
June	0	0	0	0	91	30	0	26	0	0	0	0	0	0	0	0	5	0	4	44
July	0	0	0	0	78	27	0	0	0	0	0	0	0	0	0	0	0	0	22	73
August	0	3	0	0	81	19	0	0	0	0	0	0	6	0	0	0	0	0	13	78
September	0	0	0	0	100	62	0	0	0	0	0	0	0	5	0	0	0	9	0	24
October	0	12	0	0	96	48	0	0	0	0	0	0	0	0	0	0	0	0	4	40
November	0	0	0	8	92	72	8	8	0	0	0	0	0	0	0	0	0	0	4	12
December	20	90	0	5	75	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5

bid water, providing it has been coagulated and settled.

Rate of Flow.—Downward flow filters were operated at rates from 2 to 4 gal./sq. ft./min. Higher rates could have been employed but it was found that odor removal efficiency decreased as the rates increased so that for our own particular problem rates above 4 gal. were considered prohibitive. In a special experiment for chlorine removal only conducted in a bed of Darco 16 ft. deep, rates up to 135 gal./sq. ft./min. were employed for short periods.

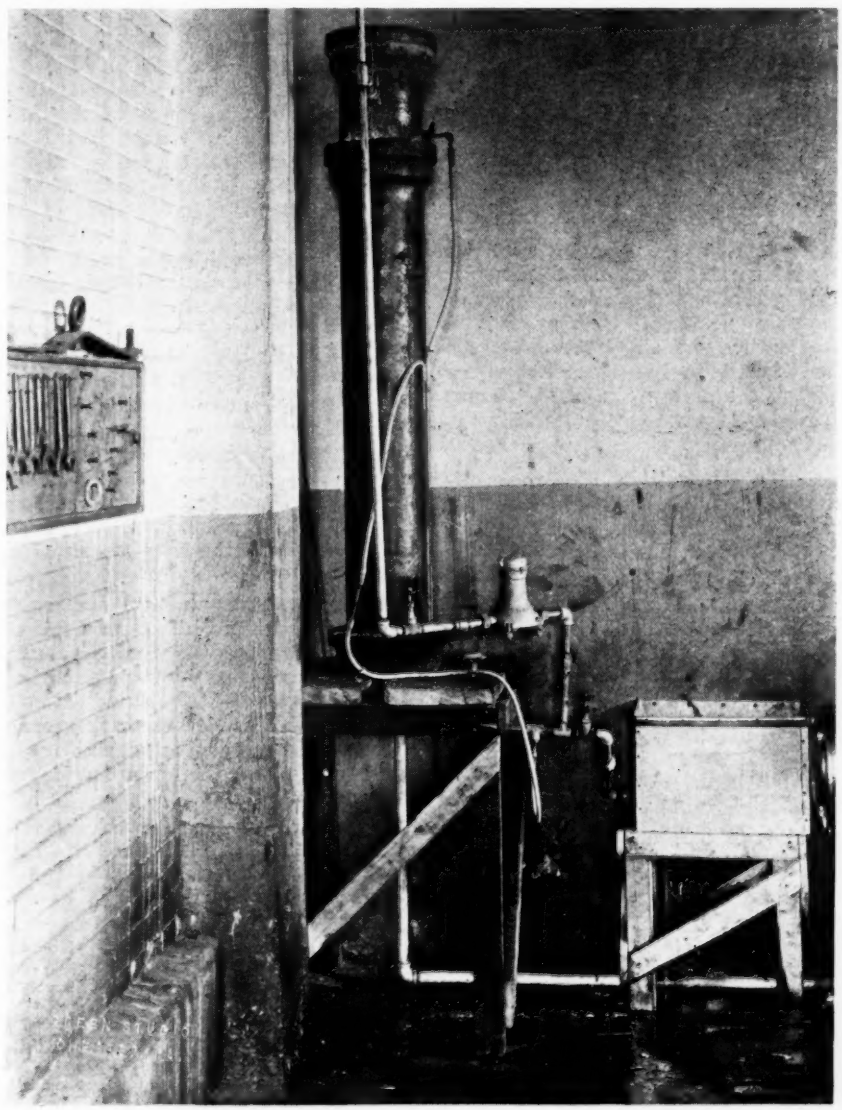
Upward flow filters were operated at rates from 2 to 3 gal./sq. ft./min. With the freeboard available in our filters the maximum upward rate without appreciable loss of material was 2 gal. for Nuchar and 3 gal. for Darco.

Loss of Head and Length of Runs.—Data on loss of head and length of runs is summarized in Table IV. Somewhat irregular figures were recorded on the same filter at different times and these features semed to depend to some extent on the arrangement of the particles of the bed after washing. In some instances the length of run was quite short when a new filter was first placed in service but after a few washings the run increased to normal probably because of loss of fine material on washing. Filter No. 6 operating on coagulated water behaved like a normal rapid sand filter as regards loss of head and length of run.

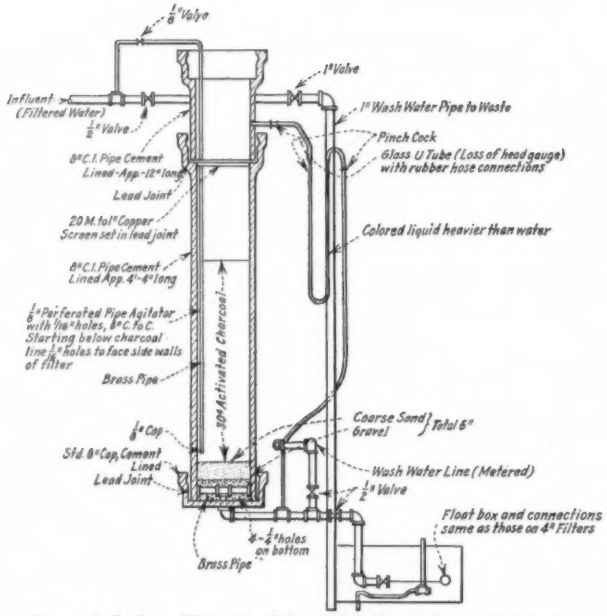
Washing.—Upward flow filters do not require washing under normal conditions. However, after about 5 months of operation some clogging was noted in Filters 7 and 8 and was found to be due to accumulations of material in the gravel. This condition was practically eliminated by alternate flooding and releasing the water in a downward direction. Similar accumulations gathered in the upper portion of the carbon on the downward flow units and resisted efforts to remove them with wash water. These accumulations may be attributed to iron from the pipe lines and possibly to particles of lime from the secondary lime treatment.

The first of the carbon filters were equipped with 20-mesh copper screens to hold the carbon down when washing. These screens were found to interfere with washing by preventing the expansion of material and were later removed. While the screens were in place a rate of wash of 15 gal./sq. ft./min. was used and this was the rate employed on the Minchar filters at all times. After the removal of the screens a gal./sq. ft./min. rate of wash was employed on all units except the Minchar.

Regeneration. — Experiments have demonstrated that when the carbon begins to lose its efficiency for removing odors it can be regenerated, at least partially, by the use of steam or hot air. Since steam under pressure was readily available it was used exclusively in the practical experiments under discussion. The method was simply to drain the filter and apply steam slowly into the under drains until the whole mass was heated to boiling temperature, where it was maintained until the steam rising from the top of the filter was relatively free from odor. The time required to accomplish this was from 20 to 30 minutes and in some cases a filter was steamed for two such periods with a normal wash between steamings. It was very interesting to stand above the filters while they were being steamed and to observe the odors which were driven off. During the earlier part of the process the lighter hydrocarbons and other volatile materials predominated later giving way to the odor of heavier oils and unpleas-



Experimental Filter Used in Activated Carbon Experiments


1" Valve
Influent (Filtered Water)
½" Valve
1" Valve
1" Wash Water Pipe to Waste
Pinch Cock
Glass U Tube (Loss of head gauge) with rubber hose connections
6" C.I. Pipe Cement Lined-App. 12" long
Lead Joint
20 M. to 1" Copper Screen set in lead joint
Colored liquid heavier than water
6" C.I. Pipe Cement Lined App. 4'-4" long
¼" Perforated Pipe Agitator with 1/16" holes, 6" c. to c. Starting below charcoal line ¼" holes to face side walls of filter
Brass Pipe
30" Activated Charcoal
Coarse Sand
Gravel
Total 6"
¼" Cap
Std. 6" Cap, Cement Lined Lead Joint
Wash Water Line (Metered)
½" Valve
Float box and connections same as those on 4" Filters
4-¼" holes on bottom
Brass Pipe

Type of Carbon Filter Used in Activated Carbon Experiments

ant organic material. The results indicate that the ability of the filter to remove odors is restored, to a great extent, by this treatment. It appears, however, that the period of effective operation may decrease after each regeneration and the presumption is that a point would ultimately be reached when nothing would be gained by further regeneration and the carbon would have to be removed and replaced or else reactivated in retorts or by some other method, if this is possible. The length of time before the material reaches a point where regeneration with steam is unsatisfactory cannot be stated definitely, but it probably depends on the material used, the water treated and the rate of filtration employed.

Practical Application of Carbon Filtration on a Large Scale.—A full discussion of the practical application of activated carbon on a large scale is beyond the scope of this paper.

Baylis has suggested that the carbon be placed in a specially designed compartment located in the clear well and that the sand filter effluent be passed upward through the carbon. This arrangement might prove advantageous for certain waters where the function of the carbon is to remove residual chlorine and small amounts of phenol or similar odorous compounds. Obviously this arrangement could not be readily adapted to regeneration in place with steam.

In those cases where it is desirable or necessary to employ carbon filtration on the site of an existing gravity type filtration plant the carbon could be placed in pressure filter units and inserted on the discharge side of the high duty pumps. In the case of an existing pressure filter plant the carbon pressure units could be placed in series following the sand units. Either downward or upward flow types might be used with this arrangement. The danger of particles of carbon being carried into the distribution system would be prevented with downward flow type by the layer of sand beneath the carbon. However it appears that this danger could be minimized and perhaps eliminated in the upward flow type by placing the outlet at a point sufficiently above the level of carbon in the filter.

In those cases where water is pumped from a filtration plant to an open storage reservoir before passing into the distribution system the carbon filter plant could be located at the reservoir. In this case the carbon units might be either open or pressure type, operated on either the upward or downward flow principle.

In any case, the carbon units should be so designed as to permit the application of steam through the under drains in sufficient quantity to maintain a temperature of 212° F. for a half hour or longer. A suitable vent should be provided on closed type units to permit the escape of vapors during regeneration. A steam generating plant of proper size and suitable wash water facilities would be required.

Table IV—Summary of Results for Loss of Head and Rate of Flow

Filter No.	Rate Gal./ sq. ft./ min.	Loss of Head Feet		Length of Run in Days Between Washings			Material
		Initial	Final	Ave.	Max.	Min.	
1	2	0.20	3.5	48	78	26	Nuchar
2	4	0.57	6.8	28	29	26	Darco*
3	2	0.47	4.4	23	39	10	Nuchar
4	3**	1.10	3.2	26	42	10	Nuchar
5 (1st period)	2	1.10	4.8	3	6	0.3	Darco
5 (2nd period)	2	0.6	3.8	28	40	22	Darco
6 (settled water)	2	0.5	5.4	4	6	2	Minchar
7	2	0.9	....	Indeterminate			Nuchar
8	3	0.6	....	Indeterminate			Darco

* Preliminary run with Nuchar not included.
** Preliminary run at 4 gallon rate not included.

Summary.—During the year 1929 a number of experiments have been conducted on a river water containing objectionable odors with a view to producing a drinking water which would at all times be free from appreciable odor or taste.

In all except one experiment the raw water was purified by passage through a rapid sand filter plant before being applied to the carbon filters. In the remaining experiment coagulation basin effluent was applied.

Comparing the respective efficiencies of the different materials used for odor removal at a given rate of filtration, these experiments indicate that Darco is superior to either Nuchar or Minchar. The difference between the last two is not so marked but the advantage is definitely in favor of Nuchar.

The harder materials like Minchar, which also have a lower carbon content, have an advantage in that they can be used in place of sand with coagulated water. The softer carbons like Darco and Nuchar are not applicable to direct filtration of raw or coagulated water but should be used on waters from which turbidity and organic matter have been removed.

On the particular water studied in these experiments a rate of filtration of 2 gal./sq. ft./min. gave best results. Lower rates were not tried but might have given better results on Nuchar and Minchar. Higher rates tended toward a decrease in efficiency.

It is possible to operate carbon filters with either upward or downward flow. Where conditions are favorable upward flow is to be preferred because head losses are small and washing is practically eliminated. On the other hand our experiments indicate that odor removal is not as good with upward as with downward flow even though a thicker carbon bed is used.

Under the conditions of this experiment it appears that a 30 in. bed of Darco operating on purified water at a 2 gal. rate will remove appreciable odor for about one year without regeneration.

The passage of steam through beds of Darco or Nuchar so as to maintain a boiling temperature for about a half hour will remove a quantity of the substances which have been absorbed by the carbon. It is probable that this process does not amount to complete regeneration of the material and that ultimately the capacity of the carbon to remove odor and taste will become impaired to such an extent as to require its removal and replacement

with new or completely regenerated material.

Objectionable odors in water due to minute quantities of industrial waste can be removed by means of activated carbon. With the new and improved carbons which are being developed it is reasonable to anticipate that even better results will be secured in future than those reported in this paper.

The work described in this paper was carried out under the general direction of Mr. T. H. Wiggin, Chief Engineer, Public Works Engineering Corporation, and Mr. Robert Spurr Weston, of Weston & Sampson, Consulting Sanitary Engineer.

Acknowledgment—The foregoing is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

Progress of Research on Dams

American research into the problem of dams, one of the major issues of the World Power Conference in Berlin, is assembling a large body of scientifically determined facts which will be made available to engineers and government commissions in all parts of the world, it is announced by H. Hobart Porter, chairman of the Engineering Foundation and president of the American Water Works & Electric Co.

The decision of the International Large Dams Commission to become a subcommittee of the World Power Conference has opened the way to exchange between engineering bodies which will be a valuable factor in preventing disasters. Recent tests made in this country also indicate methods which will bring about important savings in the cost of great engineering projects.

In 1923 the Engineering Foundation began an investigation of arch dams. A concrete dam 60 ft. high was built in a canyon in the Sierra near Fresno, Calif., and subjected to a variety of experiments and precise measurements at a cost of more than $100,000.

To supplement this large-scale experiment, tests were made in the laboratories of Princeton University by Prof. George E. Beggs on models in celluloid of this Stevenson Creek Dam. The first model was a replica of the dam as built but only one-fortieth of its linear dimensions. Later, tests on two other celluloid models were made by Prof. Beggs, and these have only recently been completed. One of these models represents the Stevenson Creek Dam as if built to a height of 80 ft. and the other as if built to a height of 100 ft.

These recent tests on the additional celluloid models indicate that the Stevenson Creek Dam, with its thickness of only 2 ft. of concrete, excepting at its very bottom in the V of the canyon, would have stood if the reservoir had been filled with water to the top of the dam. The models have indicated the ways in which the forces are distributed throughout the dam and the ways in which it would bend under the pressure of water in the reservoir, disclosing the true mathematical nature of the structure.

These experiments have made available to engineers some carefully determined facts to replace many assumptions. The interesting question is raised as to whether it would be worth while to spend a large sum of money in building the existing experimental concrete dam to a height of 100 ft., installing expensive instruments and testing it as the present 60-ft. dam was tested. Some persons would like to see how the experimental concrete dam really would break if built high enough to give way under the pressure of the water. The committee is now considering his question.

The agreement between the results obtained on the dam and upon the first celluloid model was so close that there appears to be good justification for accepting other tests when properly made on other models of dams.

For a further check, tests were made with the co-operation of the Bureau of Reclamation under Commissioner Elwood Mead and Chief Engineer Raymond F. Walter of the Denver office; by John L. Savage, designing engineer; Ivan E. Houk, research engineer of the Bureau, and by Prof. H. J. Gilkey of the University of Colorado, with the assistance of Dr. Fredrik Vogt of Trondhjem, Norway. These tests were made in the laboratories of the University and corroborated the former results. Tests of other dams built or proposed by the Bureau of Reclamation were also made, and these results have been very thoroughly studied by the engineers conducting them and by others, especially Dr. H. M. Westergaard of the University of Illinois and Dr. Vogt.

To supplement these tests of large and small models, there are in progress field examinations of large dams built for practical use in Mexico, Arizona, California, Oregon, Washington and Montana.

The Engineering Foundation, as the agency of the national engineering societies, is also co-operating with a committee of the American Society of Civil Engineers interested in other types of dams. The Bureau of Reclamation is continuing its studies and other organizations are devoting attention to dams, so that a large body of scientifically determined facts may be available to engineers designing, building and maintaining dams in all parts of the world, and to regulatory commissions of government.

At the University of California, furthermore, there have been in progress for the last few years very precise tests on the concrete used in the Stevenson Creek Dam. By this research, Prof. Raymond E. Davis has brought out some interesting characteristics of the concrete used for many kinds of structures nowadays which were not previously understood. This is an important addition to the art of designing and building dams and other structures of concrete.

Prof. Charles D. Marx of Leland Stanford University is chairman of the Committee on Arch Dam Construction, Mr. Porter said, and Fred A. Noetzli of Los Angeles is secretary. Harry Hawgood is chairman of the sub-committee on the construction and test of the Stevenson Creek experimental dam, which was built under the general direction of H. W. Dennis, chief civil engineer of the Southern California Edison Company. The work was supervised by Prof. W. A. Slater, then of the Bureau of Standards and now in charge of the John Fritz laboratory at Lehigh University. Prof. Slater also conducted the thousands of tests on the Stevenson Creek Dam and prepared a large part of the report.

Water Waste to Be Reduced by New Building Code of New York City

The plumbing recommendations of the subcommittee on plumbing of the Merchants Association Committee of New York City which is preparing a new building code for the city contains a suggestion which if adopted will result in the saving every day of millions of gallons of water which now runs to waste in homes and office buildings.

John J. Dietz, Commissioner of Water Supply, of New York City, for several months has been carrying on an active campaign to prevent the unnecessary use or the waste of water. He recently made an inquiry, which disclosed that the close proximity of hot and cold water pipes in thousands of buildings is the cause of millions of gallons of waste. It has been a common practice to place the pipes so closely together that the cold water pipes absorb enough heat to make them warm or even hot. When users turn on the cold water tap they are obliged to let the water run for from thirty seconds to a minute before cold water is obtained. The aggregate loss of water is enormous and both Commissioner Dietz and Commissioner Brady of the Bureau of Buildings in Manhattan have asked the code revisers to correct the situation.

In devising the new code, the problem has been met by providing that where hot water supply systems are installed, the hot water riser shall be covered with approved insulating material unless the hot and cold water risers are at least 6 in. apart. It is figured that a hot water pipe 6 in. or farther away from a cold water pipe will not have material effect on the temperature of the latter.

Efficiency of Chlorination at Chicago

An Interesting Description of the Highly Organized Chlorination Control System of This City and the Results Obtained

By H. H. GERSTEIN

Sanitary Engineer, Division of Water Safety Control, Bureau of Engineering, City of Chicago

A STUDY of the data obtained during five years of chlorination in Chicago, Jan. 1, 1925, to Dec. 31, 1929, which includes the results of bacterial analyses of over 50,000 samples of raw chlorinated water, shows that Great Lakes water of widely varying pollution may be treated by chlorination alone to produce a safe drinking water which is well within the U. S. Treasury Department standard, providing that strict supervision is maintained over the treatment at all times.

Quality of Raw Water.—Chicago obtains its water supply from Lake Michigan through six intake cribs located along the lake front at distances varying from 2 to 4 miles from shore. The quality of the water at any one of these cribs, no matter how near or far from the sources of pollution, may vary within wide limits within a short period of time, from a practically sterile to a moderately or grossly polluted water, or vice versa. This condition is due to the fact that the pollution is carried by wind induced currents which vary with every change of wind direction. The most southerly intake—the Dunne Crib—being nearest to the highly polluted section of the lake off the Calumet industrial region, obviously receives the most polluted water. The quality of the water at the other intakes varies with the distance from shore and from the sources of pollution.

Table I is a summary of the frequency of occurrence of various degrees of pollution at the intakes. It will be noted that the frequency of the greater pollution is low. This, however, is no criterion of the difficulties encountered in the treatment of the water; the raw water may at any time, without warning, become highly polluted.

Figure 1 shows in chart form the percentage frequency of occurrence when the B coli content of the raw water at the various intakes was equal to or greater than 10, 100 and 1,000 B coli per 100 cc.

Chlorination Control.—Since treatment with chlorine is the only line of defense in protecting the quality of its public water supply, Chicago has

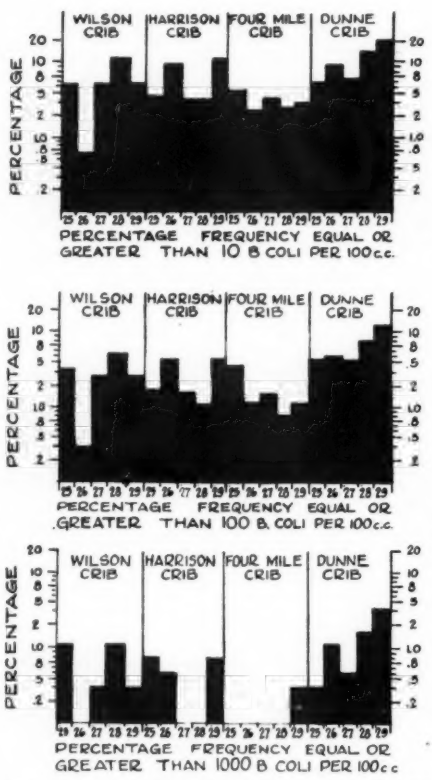

WILSON CRIB
HARRISON CRIB
FOUR MILE CRIB
DUNNE CRIB
PERCENTAGE
PERCENTAGE FREQUENCY EQUAL OR GREATER THAN 10 B COLI PER 100 c.c.
PERCENTAGE FREQUENCY EQUAL OR GREATER THAN 100 B COLI PER 100 c.c.
PERCENTAGE FREQUENCY EQUAL OR GREATER THAN 1000 B COLI PER 100 c.c.

Fig. 1—Frequency of Occurrence of B coli Per 100 cc. (Phelphs), 1925-1929

of necessity developed a highly organized chlorination control system. The chlorine is applied at each of the 12 pumping stations at a point before the water reaches the suction of the pumps. In order to insure continuity of operation, all the chlorination equipment is in duplicate. A man is on duty at each pumping station at all times, whose only work consists of operating chlorination apparatus, performing control tests and keeping records of these tests. Control tests consist of hourly checks on the operation of the chlorinators by determining the loss of weight of the chlorine cylinders, and hourly orthotolidin tests for residual chlorine. During periods when the chlorine absorbing qualities of the water are on the increase, these tests are made as often as every 15 minutes. In addition, there are daily checks on operation by means of bacteriological analyses of samples of raw and chlorinated water, collected at each of the pumping stations, and from the distribution system; also independent daily checks are made of the chlorine battery scale weights and residual chlorine tests. The equipment is kept in first class condition at all times by frequent cleaning and servicing.

Special attention is paid to the meteorologic conditions, such as winds, rainfall and lake levels, all of which have great influence on the discharge of pollution into the lake, and the carrying of this pollution to the intakes. A study of these condtions makes it possible to forecast the pollution to be expected at the various intakes and to determine the minimum chlorine dosages which can be carried with safety at the various pumping stations. The residual chlorine test is considered the most important gauge of the effectiveness of chlorination. Since under ordinary conditions it is not practicable to make these tests oftener than once each hour, and since the quality of the water may change without the knowledge of the operator between these hourly tests, it is at present desirable to forecast the maximum pollution to be expected at each of the intakes and to regulate the dosages accordingly. It is endeavored to maintain at all times at least 1 to 2 lb. per million gallons of residual chlorine after a 10-minute contact. Under ordinary conditions the residual chlorine runs higher than this because of the factor of safety used to take care of sudden changes in chlorine absorption.

Table II is a summary of the average and maximum chlorine applied to the water from the various intakes. The average for all intakes for the period was 3.77 lb. m.g.; the Wilson and Harrison cribs averages of 3.39 lb. m.g. were the lowest; and that of the Dunne crib, 4.33 lb. m.g., was the highest. The maximum dosage for the period of 14 lb. m.g. was applied during 1927 to the Dunne crib water.

The high dosages were necessitated by the presence at times of chlorine absorbing substances in the water. At such periods the ordinary dosages of chlorine applied are entirely absorbed, leaving no residual chlorine to do the work of disinfection. It is then necessary to apply sufficient chlorine to satisfy the chlorine demand, plus an additional amount for residual chlorine. The chlorine absorbing substances may

Table I—Percentage Frequency of Occurrence of B coli in Raw Water at Crib Intakes; 1925-1929

Crib Intake	Year	Number of Sampling Days	Percentage Frequency of Occurrence, by Days, B coli per 100 cc. 0	2	4	6	8	10	100	1,000	10,000
Wilson	1925-29	1,826	45.3	26.2	12.0	7.4	3.7	2.6	2.2	.5	.11
Harrison	1925-29	1,825	47.3	21.3	12.7	7.6	4.3	3.8	2.6	.4	....
Two-Mile	1929	365	38.4	21.1	12.6	9.1	5.8	6.6	4.7	1.9	....
Four-Mile	1925-29	1,825	55.9	21.2	10.7	5.7	2.5	1.9	1.6	.05	....
Dunne	1925-29	1.825	45.7	18.3	10.6	7.1	5.7	5.5	5.2	1.3	.11
All cribs	1925-29	7,666	48.2	21.8	11.5	7.1	4.2	3.6	3.0	.6	.05

Table II—Chlorine Applied to Water from Each Crib Intake; 1925-1929

Crib Intake	Chlorine Applied (Lb. per 1,000,000 Gal.) 1925	1926	1927	1928	1929	1925-1929
Wilson—						
Average	2.98	3.56	3.37	3.29	3.64	3.39
Maximum	5.5	5.0	9.25	7.0	9.0	9.25
Harrison—						
Average	3.19	3.54	3.30	3.25	3.67	3 39
Maximum	4.5	5.0	4.25	6.0	8.0	8.0
Two-Mile—						
Average	.....	.....	.....	.....	4.08	.....
Maximum	.....	.....	.....	.....	10.0	.....
Four-Mile—						
Average	3.56	3.50	3.36	3.25	3.58	3.45
Maximum	5.5	5.0	4.5	4.5	6.0	6.0
Dunne—						
Average	4.07	4.27	4.33	4.27	4.56	4.33
Maximum	5.5	7.0	14.0	10.0	13.0	14.0
All cribs—						
Average	3.50	3.78	3.69	3.68	4.04	3.77
Maximum	5.5	7.0	14.0	10.0	13.0	14.0

Table III—Relation Between B coli Index of Raw and Chlorinated Water at Chicago; 1925-1929

Raw Water Average B coli per 100 cc.	Number Crib Days	Chlorinated Water Average B coli per 100 cc.	Number of Samples
0, 2, 4 Avg. .63	5,355	.042	30,498
6, 8, 10 Avg. 5.98	2,025	.067	12,367
100	233	.074	1,590
1,000	48	.187	353

be divided into two types, the first being industrial and sewage wastes which are discharged into the lake from the Calumet region. Recent tests have shown that the dilution of as little as one part of ammonia still liquor in 10,000 parts of lake water will increase the chlorine absorbing properties of the water materially. The second type of chlorine absorbing substances are the finely divided particles, organic and inorganic, which are thrown into suspension by prolonged, severe lake storms.

Efficiency of Chlorination.—The results of bacteriological analyses of the samples of raw and chlorinated water were studied for the purpose of determining the efficiency of chlorination as practiced in Chicago. These studies were made along the lines followed by Streeter* in his studies of the efficiency of Water Purification processes of plants on the Ohio River and Great Lakes.

The bacterial analyses were made in accordance with Standard Methods at the Chicago Health Department laboratories. The B coli index for routine records is calculated by McCrady's method of probable numbers, but in order to make the results presented in this paper comparable with similar studies, the B coli index has been calculated by the Phelp's method. The data may be taken to cover the results of five years of operation of a large number of individual chlorination plants; each of the various intakes can be considered to receive water of different bacterial quality on the same day, and the water from each of the intakes is distributed to two or more pumping stations, at which it is chlorinated separately. For the purposes of this study, the results of bacterial analyses of the chlorinated water from all pumping stations supplied by a single intake are grouped together. A single sample from the first sampling point of each crib tunnel system was taken to represent the daily quality of the raw water at the intake. The results of analyses of samples collected from the Two-Mile Crib system were omitted for the years 1925 to 1928 because the water was prechlorated at the crib during this period and therefore no record of the bacterial quality of the raw water was available.

These data are divided into various groups, according to the degree of pollution of the raw water and the corresponding quality of the chlorinated water, and the averages of these groups are calculated, as shown in Table III. Figure 2, a chart which is plotted on a double logarithmic scale from the data in Table III, shows the relation between the B coli index of raw and chlorinated water. It may be readily seen that there is a distinct relationship between the quality of the raw and chlorinated water, the points plotted adhering very closely to the straight line for which an equation may be obtained. This relation is similar to that found by Streeter* and Wolman† in their studies of efficiencies of purification processes. The slope of the line plotted would indicate that with the method of chlorination practiced in Chicago, a raw water having an index of 5,000,000 B coli per 100 cc. may be treated to produce an effluent which will pass the U. S. Treasury Standard. No such efficiency can be attained in practice because of the fact that as the pollution becomes greater the chlorine absorbing substances in the water increases, making the maintenance of sufficient residual chlorine for disinfection increasingly difficult and requiring abnormally high dosages of chlorine. Even under present conditions it is difficult to maintain residual chlorine in the water during certain periods. It is only by strict supervision over chlorination, and high dosages at times, that the present efficiencies can be maintained.

The chlorinated water has at all times passed requirements of the U. S. Treasury Department standard for a safe water. Table IV is a summary showing how chlorinated water corresponding to various degrees of raw water pollution met these requirements.

Influence of Turbidity on Efficiency.—From the purpose of studying the effect of turbidity of the raw water on the efficiency of chlorination, the data is sub-divided into groups of similar turbidity, as shown in Table V. This data which is plotted in chart form in Fig. 3, shows strikingly that the efficiency of chlorination decreases with

*Public Health Bulletins Nos. 172 and 193—"Studies of Efficiency of Water Purification Processes"—H. W. Streeter.

†"Degree and Nature of Bacterial Removal"—Jour. A. W. W. A., September, 1918, by A. Wolman.

Table IV—Summary Showing How the Chlorinated Water Corresponding to Various Degrees of Raw Water Pollution Met the Different Requirements of the U. S. Treasury Department Standard for a Safe Drinking Water; 1925-1929

Raw Water Average B coli per 100 cc.	Chlorinated Water Average B coli per 100 cc. Max. Allowed—1.0	Percentage of 10 cc. Portions Positive Max. Allowed—10%	Percentage of Samples Which Were 6 B coli per 100 cc. or More Max. Allowed—5%
0, 2, 4 Avg. .625	.042	.42	.15
6, 8, 10 Avg. 5.98	.067	.67	.25
100	.074	.74	.50
1,000	.187	1.87	.567

Table V—Influence of Turbidity on Relation Between B coli Index of Raw and Chlorinated Water at Chicago; 1925-1929

Raw Water Average B coli per 100 cc.	Raw Water Turbidity p.p.m.	Number Crib Days	Chlorinated Water Average B coli per 100 cc.	Chlorinated Water Number of Samples
0, 2 Avg. .65	0—9	3,391	.0368	18,473
.565	10—49	1,993	.0433	11,966
1.21	50 over	71	.158	450
4, 6, 8, 10 5.92	0—9	1,168	.0442	7,110
Avg. 6.06	10—49	779	.082	4,447
6.77	50 over	121	.146	723
100	0—9	133	.070	973
	10—49	69	.063	431
	50 over	31	.124	192
1,000	0—9	21	.0835	168
	10—49	12	.27	89
	50 over	15	.292	

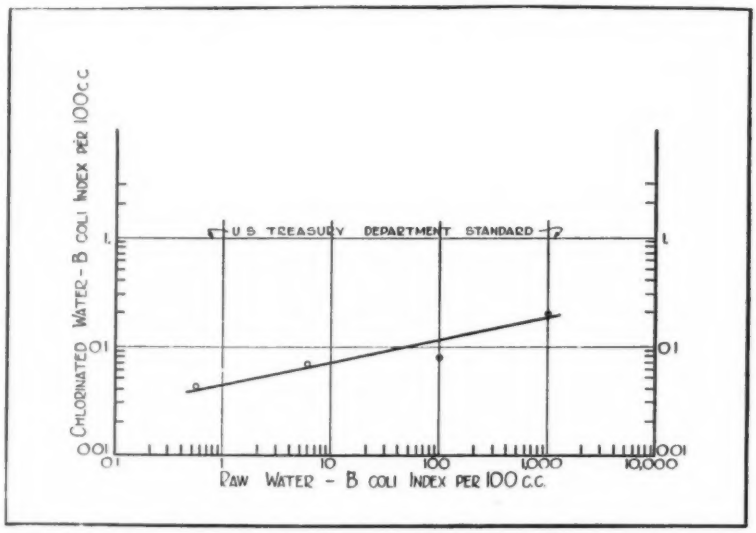


Fig. 2—Relation Between B coli Index of Raw and Chlorinated Water at Chicago, 1925-1929

increased turbidity. A small factor in this trend may be that with increase in turbidity there are also increases in chlorine absorptive properties, which make chlorination more difficult. This, however, accounts for only a small portion of the trend, because an increase in chlorine absorption due to this cause is not observed until the turbidity becomes quite high.

Future of Chlorination at Chicago.—During the last few years there has been an increasing trend in the pollution of the lake water off Chicago, mostly by wastes discharged from the Calumet region. The indications are that pollution will continue to increase, especially in light of the recent Supreme Court decision which ruled that diversion from Lake Michigan into the Drainage Canal should be progressively reduced in the next nine years. It is estimated that during 1929, 6,500,000,000 gal. of water having abnormal chlorine absorptive properties were pumped into the distribution system or approximately 1.7 per cent of the total yearly pumpage.

Production of a safe drinking water by chlorination alone will become increasingly difficult. The higher chlorine dosages required at times for effective disinfection will cause objectionable tastes and odors. This, coupled with the turbidity after each storm on the lake and the obnoxious algae tastes and odors, will make the water more and more unpalatable, until a time will come when the public will refuse to use it for drinking and domestic purposes. Such a condition would probably produce grave physiological effects on the health of the citizens of Chicago.

Tests have shown that filtration will easily produce a satisfactory water. Chicago must make a determined effort to install such plants as soon as possible.

Acknowledgment.—The foregoing is an abstract of a paper presented June 5 at the 50th annual convention of the American Water Works Association.

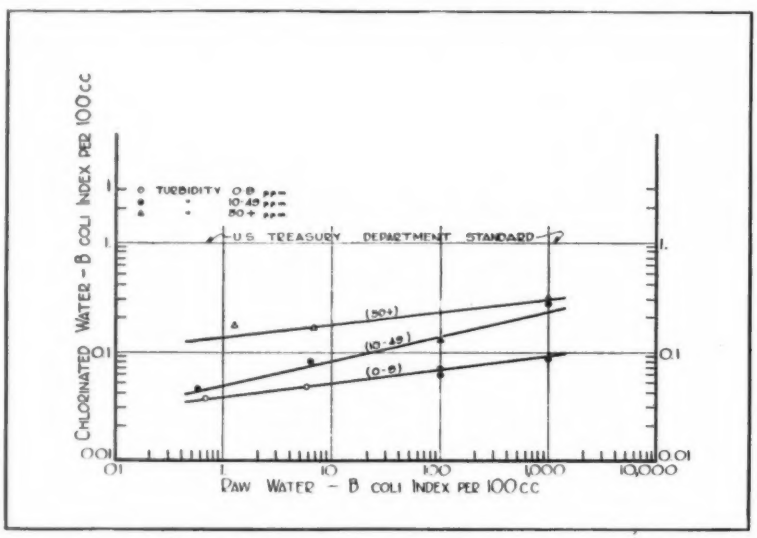


Fig. 3—Influence of Turbidity on Relation Between B coli Index of Raw and Chlorinated Water at Chicago, 1925-1929

Status of Sewage Treatment at Chicago

The status of the sewage treatment construction program of the Sanitary District of Chicago on June 1, 1930, was as follows, according to the semi-annual report of the district:

Completed Work as of June 1, 1930

Des Plaines River Project	$ 4,005,843.06
Calumet Project	19,375,028.09
North Side Project	35,889,832.75
West Side Project	30,278,128.22
Southwest Side Project	192,753.73
Miscellaneous plants and sewers	521,060.20
Chicago River Controlling Works	53,415.74
Total	$ 90,316,061.79

Future Work After June 1, 1930

Des Plaines River Project	$ 4,214,476.47
Calumet Project	20,274,893.93
North Side Project	5,964,678.68
West Side Project	64,234,806.57
Southwest Side Project	70,624,246.27
Miscellaneous plants and sewers	9,981,537.86
Chicago River Controlling Works	3,946,584.28
Total	$179,241,224.04

Further particulars on the progress of the program are given as follows in the report:

The estimated population of The Sanitary District of Chicago for the year 1930 is 3,710,000. The industrial wastes in the Sanitary District are estimated as equivalent to the sewage of 1,732,000 additional persons, hence the total population and industrial wastes equivalent amount to 5,442,000. This includes the Corn Products wastes, equivalent to the sewage of 432,000 persons which wastes have been greatly reduced as a result of certain experimental work initiated by the Sanitary District.

The sewage treatment construction accomplished, in compliance with the March 3, 1925, permit from the Secretary of War, up to Dec. 31, 1929, amounted to the equivalent (100 per cent) sewage treatment of 1,442,000 persons. This included an equivalent of 361,000 for the reduction accomplished on the Corn Products wastes and further included credit for construction accomplished on projects partially completed but not in actual service. For instance, the North Side Project was 96 per cent completed but actually operating to only 40 per cent capacity and the West Side Sedimentation Project was 48 per cent completed but not in operation. The total sewage treatment, referred to a basis of 100 per cent treatment on Dec. 21, 1929, was 366,000 based on actual population treated to which the addition of 361,000 for the work at the Corn Products plant gives a total equal to the 100 per cent treatment of the sewage of 727,000.

The 1930 total population and industrial wastes equivalent as above indicated are estimated as 5,442,000. Up to date the Sanitary District has assumed that sewage treatment could produce an annual average of 85 per cent purification. Hence so-called complete treatment for the total 1930 population and industrial wastes equivalent would equal the 100 per cent treatment of the sewage of 4,625,700, which is 85 per cent of 5,442,000.

Preammoniation of Filtered Water

Treatment at Filtration Works, Cleveland, O., by Means of Large Plant Installation of Ammonia Equipment

By J. W. ELLMS

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THE use of ammonia for the prevention of objectionable tastes in drinking water which is disinfected with chlorine depends on the presumable formation of chloro-amines. The chemistry of the reactions involved when ammonia is applied to a natural water prior to chlorination is more or less obscure. It seems probable, however, that the formation of monochloro-amine and dichloro-amine are dependent upon the hydrogen-ion concentration of the water being treated. Probably in naturally alkaline waters a mixture of these two amines results. The combination of chlorine or hypochlorous ions with phenolic compounds, when the latter are present, to form chlorphenolic bodies producing foul tastes, is apparently prevented by the presence of the ammonia.

The theoretical ratio of NH_3 to Cl to form monochloro-amine is 1 to 4.2; and for the dichloro-amine it is 1 to 8.3. Under acid conditions a theoretical ratio of 1 to 3.12 produces NCl_3; and under alkaline conditions a theoretical ratio of 1 to 1.55 forms nitrogen gas. It is, therefore, probable that two great an excess of ammonia is liable to prevent the formation of chloro-amines, while an insufficient quantity may result in an excess of chlorine with the consequent formation of chlor-phenolic taste-producing compounds, should phenols be present. Within the range of pH values for most water supplies, there is probably formed a mixture of the monochloro- and dichloro-amines.

The disinfecting property of the chloro-amines is well established, and it is, therefore, desirable to provide if possible the optimum conditions for their production when depending upon them for bactericidal action. They have a somewhat slower action than does chlorine used alone, but they have a continuing inhibitory effect upon bacterial growths which is of great value for maintaining a water supply in good condition during its passage through pipe lines and reservoirs to the consumers. These facts have been confirmed in our experimental work.

Important Facts Established by Experimental Work.—The experimental work in Cleveland was primarily undertaken in order to find (1) An effective preventive of objectionable tastes produced by the occasional presence of small quantities of phenolic compounds, and (2) To prove the bactericidal properties of the process. For these purposes both laboratory and small plant scale experiments were made, and as a result a large amount of data was collected. It will only be possible in this paper to briefly indicate the important facts established in connection with the treatment of filtered Lake Erie water.

These points may be concisely stated as follows:

1. The application of anhydrous ammonia gas to a filtered water prior to its chlorination prevents objectionable tastes from chlor-phenolic compounds even when phenol is present in a concentration of one part per million.
2. Boiling the water thus treated does not develop the objectionable taste of chlor-phenolic compounds.
3. Chlorinous odors and tastes, which are not uncommon when chlorine is used alone, are also prevented.
4. The compounds formed by treating the water with ammonia before applying the chlorine are relatively more stable than those produced by adding chlorine only, as shown by "residual chlorine" tests, and by a prolonged inhibitory effect upon bacterial growths.
5. The process requires a small amount of inexpensive equipment, which may be used at existing water plants without modification of the latter, and is of low cost for operation and maintenance.

The Equipment.—Equipment for applying anhydrous ammonia gas to the filtered water before it is chlorinated was first installed in one of the city's filter plants in the fall of 1929. Operation of this equipment was started on Nov. 1, 1929, and has been continuous up to the present time. No ammonia gas control units for feeding the gas to the water being available at that time, manual control through an orifice by means of an ammonia needle valve was employed. A mercury manometer was used to measure the drop in pressure across the orifice, in addition to ammonia pressure gages placed before and after the orifice.

A large platform scale for determining by weight the amount of ammonia gas being used was placed in a room provided with steam heat. On the scale platform are laid five anhydrous ammonia gas cylinders, each of which contains 150 lb. of the gas. Flexible steel tubing is used to connect each cylinder with a valved manifold or header, on one end of which was placed an ammonia pressure gage. From the opposite end of the header a ⅜-in. iron pipe conveys the gas to the section containing the orifice plate, manometer and control needle valve.

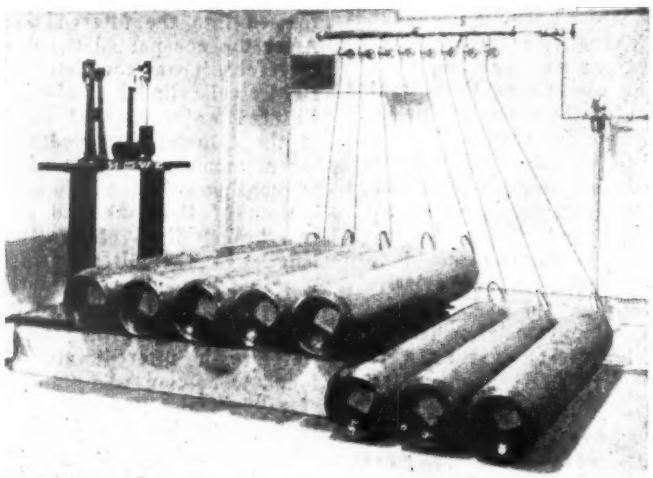
At this point the filtered water is conducted from the plant by two 54-in. diameter cast-iron pipe lines into a concrete twin conduit. Feeding the gas directly into these two pipe lines was not at first thought to be practicable, and, in consequence, it was decided to attempt to dissolve the gas in water and to discharge the ammonia water formed into the filtered water mains. After the gas passed the needle valve, therefore, it was conducted into an upright steel cylinder or absorption tank. Filtered water sprayed in at the top of the cylinder dissolved the gas and the ammonia water formed was drawn off continuously through a pipe at the bottom of the tank and conveyed by two branch lines of practically equal length to the filtered water mains. Within two months after starting this apparatus, the 1½-in. pipe lines which had been conveying the strong ammonia water to the filtered water mains were found to be clogged by an incrustation of calcium and magnesium carbonates. In consequence, the pipes were partially cleaned out, the water spray in the absorption chamber discontinued and the ammonia gas fed directly to the filtered water in the two mains.

The ammoniated water flows a distance of about 900 ft. before the chlorine is applied in a gate house opposite the entrance to the two basins of the filtered water reservoir. This reservoir has a capacity of approximately 20 million gallons and represents on an average about 25 per cent of the daily output of the filter plant. From this reservoir the water flows to the pumping station, where it is pumped directly into the distribution system. The foregoing facts are mentioned to show the mixing and detention periods which exist under average conditions at this plant after the application of the ammonia and chlorine.

A mercury ammonia gas control valve unit has been developed for the equipment at this plant but has not as yet been installed. In spite of the usual difficulties involved in adapting a new process to an existing plant with untried equipment, the application of the gas has been unusually uniform and the results obtained satisfactory.

Ammonia Gas Unit.—At the other city filter plant a Pardee ammonia gas control unit was installed, together with the necessary platform scale, manifold, piping, cut-off and control valves. This

equipment has been in continuous use since Jan. 4, 1930, and has proved to be accurate and easily operated. At this plant conditions were such that the ammonia gas had to be applied at four points, and only a short distance upstream from the point where the chlorine was added. The filtered water is collected from four effluent galleries or reservoirs under each quarter of the filter plant. From these four reservoirs it is conveyed by four 48-in. diameter pipe lines to a concrete conduit divided into two parts by a central partition. The ammonia gas is brought from the control unit on the floor above the conduit to a central point, from which four approximately equal lengths of ½-in. iron pipe permit the gas to be discharged into the four 48-in. mains.



Ammonia Gas Control Unit, Scales and Manifold at Baldwin Filtration Plant, Cleveland, O.

The chlorine from the chlorine machines is charged through a grid into the ammoniated filtered water at the end of the collecting conduit. The treated water then passes into a small gate chamber and from thence through four large gates to two basins of a large filtered water reservoir, holding 135 million gallons. This reservoir holds about 1½ times the present output of the plant.

The ratios of ammonia to chlorine applied at the two filter plants have been purposely varied from time to time. Two pounds of anhydrous ammonia gas to 3 or 3½ lb. of chlorine per million gallons have been used at one plant, while at the other plant the quantities have varied from 1 lb. of ammonia to 2 lb. of chlorine or 1 lb. of ammonia to 3 or 3½ lb. of chlorine per million gallons of filtered water. At both plants up to the present time of writing, there have been used 27,132 lb. of anhydrous ammonia gas. This represents at one plant 1.8 lb. of ammonia gas for each million gallons of filtered water, and at the other plant 0.96 lb. of ammonia per million gallons of water. At both plants about 235 lb. of ammonia gas are applied daily to the filtered water.

Results.—The results obtained from the use of ammonia in these two large filter plants have confirmed our experimental work. No tastes from chlorphenolic compounds have been noted in the public water supply during the period the ammonia has been used. It is, of course, possible that no phenolic compounds contaminated the water supply during this period; but if they did the addition of the ammonia has effectively prevented them from uniting with the chlorine to produce foul tastes.

During the colder portions of the year, when the temperature of the water is the lowest, the residual chlorine is always the highest when using chlorine only for disinfection. Hence chlorinous tastes are more likely to be noted than when the water is warmer and the reaction between the chlorine and the water and its constituents more rapid. There has been an entire absence of these chlorinous tastes since using ammonia, although the apparent quantities of residual chlorine have been always higher as shown by the orthotolidine tests. The explanation for this fact is not apparent, but there is no doubt that the water has had a more pleasing taste since using ammonia as evidenced by statements of consumers.

The bactericidal efficiency of this process of disinfection has been carefully studied. Examinations of samples of water from widely separated points in the distribution system for their bacterial content have shown with few exceptions a water of as high a quality, if not higher, than when chlorine alone was used. Eight series of samples, which have been collected during the past six months, covered all of the various pressure service of the metropolitan district supplied with water from the Cleveland plants.

During the last three weeks in December, 1929, 147 samples of water in four series were taken on both the east and west sides of the district. The eastern portion of this area was supplied with water from the filter plant in which chlorine only was used, and the western portion by the filter plant in which both ammonia and chlorine were being used. This afforded an opportunity of comparing the effect of the two different methods of disinfection at the same time.

The average bacterial count both at 20° C. and 37° C. was 2 per cc. for samples of water which had been chlorinated only, and 0 and 0.5 per cc., respectively, for samples of water which had been treated with both ammonia and chlorine. No B. coli were found in any of the samples from either plant. The average residual chlorine for the chlorinated water was 0.013 p.p.m., and for the ammoniated and chlorinated water 0.16 p.p.m.

Four more series of samples (167 samples in all) were taken on both sides of the metropolitan district after the second filter plant had begun to apply ammonia with the chlorine. All samples gave an average bacterial count of one or less per cc. when incubated at either 20° or 37° C.; and no B. coli were found in any sample. The average residual chlorine was 0.2 p.p.m. The temperature of the water ranged between 5° and 8° C.

These results are ample evidence of the efficiency of the process when treating approximately 175 millions of gallons of water daily. They confirm our original experimental work and fully justify its adoption for Cleveland conditions.

Advantages of Process Summarized.—The advantages of the process may be briefly summarized as follows:

1. No chlor-phenolic tastes have been noted since beginning the application of the ammonia prior to chlorination.
2. Chlorinous tastes from residual chlorine have been eliminated.
3. The taste of the water is more acceptable than ever before, and no complaints from consumers have been received.
4. The bacterial efficiency of the process is as high, if not higher than when chlorine only is used.
5. The prolonged inhibitory effect on bacterial growths is of great value in maintaining a water in its highest state of purity throughout an extensive distribution system.
6. The cost of the equipment for applying ammonia is merely nominal, and may be readily adapted to any existing water plant. The cost of operation for the ammonia is low, and will not exceed $0.30 per million gallons of water treated, if the ammonia is purchased at $0.15 per lb.

Acknowledgment.—The foregoing is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

FILTRATION PLANTS

A Section Dealing with Their Design, Construction and Operation

Conducted by JOHN R. BAYLIS, Associate Editor

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Mixing Basins—Time of Mixing

THAT part of the filtration plant where the chemicals, which are used to coagulate the water, are applied, and where the mixing with the water and the reaction takes place is called the "mixing basin" or "mixing chamber." Such names as "reaction chamber," "coagulating chamber," "mixing and reaction chamber," "mixing channels," etc., also have been used to describe this part of the plant in some of the articles on filtration. The term "mixing basin" has become fairly well fixed in our minds and appears to be more appropriate than any of the other names with the possible exception of "mixing chamber." It is evident if the mixing is done in a conduit leading the water from one place to another that "mixing conduit" would be more appropriate. It is suggested that "mixing basin" be used for all cases where such a name would be appropriate, and that other names be used only where it is not appropriate to call the part where the mixing is done a basin.

The function of the mixing basin is to distribute the chemicals uniformly throughout the water and to keep the water in motion at velocity that prevents settlement of the flocculated matter.

This discussion will be limited largely to the time of mixing, with brief mention of the violence of agitation in the mixing basin. The design of mixing basins will be discussed in a later issue. The great variation in the time of mixing in use at filtration plants throughout the country indicates wide differences of opinion amongst designing engineers as to the most desirable mixing time. The writer is of the opinion that there has been more guesswork in the design of mixing basins than any other part of the plant; and perhaps justly so, for the results from different plants, or even at different times in the same plant indicate variable mixing times as being desirable.

Mixing Time Varies Widely in Existing Plants.—Mixing periods in filtration plants throughout the country will be found varying from about 3 minutes to about 90 minutes, with the majority of the basins having a mixing period of from 10 to 30 minutes. The tendency is towards a longer mixing time, and most of the newer plants provide for about 30 to 60 minutes mixing time. Different characters of water and other conditions make it desirable to use variable mixing times, but surely there should not be the wide differences that are found in the various plants.

Factors Influencing the Time of Floc Formation.—The factors that influence the time of floc formation are:

Quantity of coagulant used.
Time of mixing.
Temperature.
Violence of agitation.
Character of water.

Quantity of Chemicals.—It should be evident that the greatest factor influencing the time at which a good flocculation will form is the quantity of coagulation used. This is assuming that the alkalinity and pH are favorable for the formation of a good flocculation. The minimum quantity of chemicals necessary to coagulate the water to the extent that it will filter clear requires the longest period of mixing or stirring. A certain water with a turbidity of 10, treated with 6 parts per million of aluminum sulfate, may require 60 minutes mixing time to produce a good flocculation when the temperature is near the freezing point. If 12 parts per million of the coagulant are used, the time to produce a good flocculation may be only about 30 minutes. Three times the minimum quantity of coagulant will require a still shorter period. We might produce within 3 to 4 minutes time, with great excess of coagulant, flocculated particles as large as will be produced within 30 minutes mixing when the minimum quantity of coagulant necessary for good coagulation is used. It is largely this factor that enables the various filter plant operators throughout the country to get fairly good results when the mixing time in the plant is short.

If the turbidity of the water is 500, it might require 40 parts per million or more of aluminum sulfate to coagulate it to the extent that it will filter clear. With a temperature near the freezing point, 20 minutes mixing might produce a good flocculation when the minimum quantity of coagulant is used. In other words, water with high turbidity requiring considerable quantity of coagulant does not require quite as long a mixing period to produce a good flocculation as the same water low in turbidity.

The procedure now being followed in most filtration plants is to add sufficient coagulant to produce the desired flocculation for the particular mixing basin. The desired flocculation may vary with the length of settling after coagulation, for it is evident that a very long period of settling will produce as good clarification of the water with imperfect flocculation as a short period with perfect flocculation. When the period of mixing is short, very likely in most such plants the amount of coagulant added to the water is in excess of what would be necessary if there was a longer period of mixing. In some plants the mixing basin or mixing device produces maximum or nearly maximum efficiency, but all such plants have a fairly long period of mixing. Whatever amount of coagulant is necessary to bring the water to a condition where it can be handled without difficulty by the filters, is the amount that should be used.

Effect of Temperature.—At one time temperature was thought to have considerable influence on the quantity of coagulant necessary to use. Now it is known that its main effect is in delaying the formation of the flocculation. In such plants as have too short a period of mixing, more coagulant for a given turbidity may be required when the water is cold than when it is near the maximum temperature. This is what has given the impression to many that the lower temperature requires more coagulant. It does, if the mixing period is not long enough for the colder water. If the same quantities of coagulant are added to two samples of water from the same source, one at 1° C. and the other at 20°, the water at 20° very likely will form a good coagulation in from one-third to one-half the time of stirring as is required for the lower temperature. It seems that the differences in the time of stirring are wider when the turbidity is low and small quantities of coagulant are necessary than with higher temperatures.

The writer has not been able to detect any material difference in the

quantity of coagulant necessary to clarify water at different temperatures, providing longer periods of mixing are used for the colder waters. The fact that there are several other things that may influence the quantity of coagulant necessary for good clarification of the water, makes it difficult to take plant records and show the effect of temperature. The writer formed the opinion after observing several years' operating records at Baltimore, where there is fairly good mixing, that less coagulant was required in the colder months than in the summer months. This probably did not apply for fairly turbid water. The same thing seems to hold for the Lake Michigan water at Chicago. There no doubt are many cases throughout the country where more coagulant has to be used in the winter months for the same turbidity than in the summer months, even where there is a long period of mixing, but the cause is believed to be due to something other than temperature. It is believed that the real cause in most instances is the presence of suspended matter in an extremely finely divided state. Just why there should be more of this extremely finely divided suspended matter in the summer months is not known, and it may be that this is the case for only a few waters. At any rate we will find the plant records in some plants indicating that more coagulant is necessary for a given turbidity in the winter months, and others indicating that less is needed.

Character of the Suspended Matter.—Everyone is aware that the character of the suspended matter materially influences the quantity of coagulant. If one should plot the points of coagulant required against turbidity, for a filtration plant where there is good mixing and close supervision to see that an excess of coagulant is not used, the points would cover a range of chemicals necessary for a given turbidity in which the maximum is more than twice the minimum for any given temperature. Now the turbidity and the temperature are factors that we have to take as they are in the water, so this leaves only two things that may be varied by the designer and the operator of a filtration plant. These are time of mixing and quantity of coagulant. The designer usually sets the time of mixing, and the operator sets the quantity of coagulant. The kind of coagulant, of course, should be taken into consideration, but this is assuming the most suitable coagulant has been determined.

The extremely finely divided suspended matter is more difficult to entrap by the coagulant than the coarser particles. Some are of the opinion that the electrical charge on the particles has great influence on the ease with which it is coagulated. For extremely finely divided particles this may be the case, but for most of the suspended matter occurring in water the charge has little influence.

Filter Operator Is Limited in What He May Do.—After a plant has been constructed about the only thing the filter operator can do is to vary the quantity of coagulant. It is not so much to the operators as to the designing engineers that the writer wished to direct certain remarks. The skillful operator will do the best he can with a particular layout, but errors in design are not his fault.

If the poorly designed mixing basins were confined to those designed by engineers of limited experience it would not be so serious a reflection upon the profession, but some of the poorest mixing basins have been designed by the leading filtration engineers. It indicates that mixing basin design in the past has been largely a matter of choice or opinion, and that there are not many specific and convincing data on this subject. As the present article is limited largely to time of mixing, the design will be discussed in a later issue.

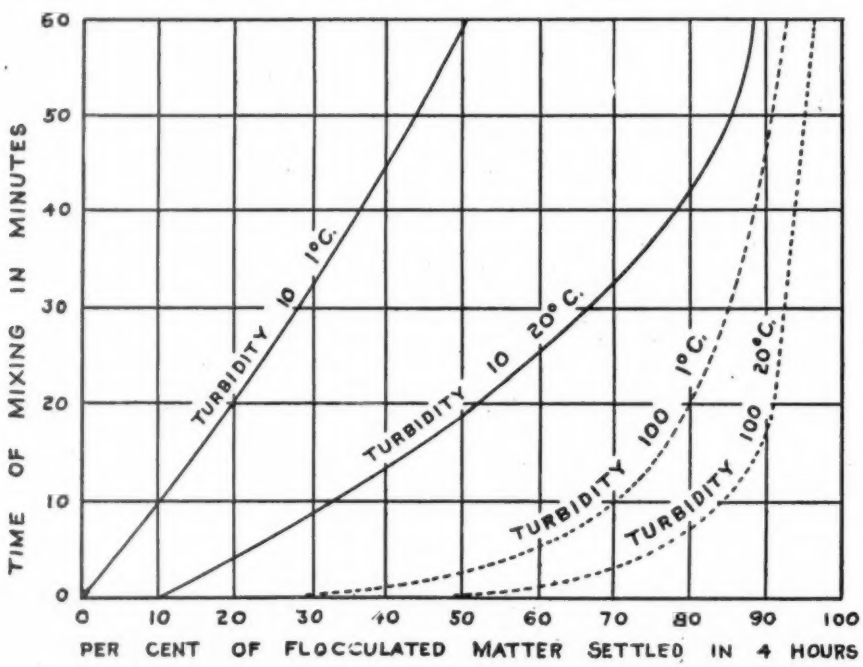

Fig. 1—Relation Between Time of Mixing and Rate of Settling

Time of Mixing.—Due to the fact that the water in a filtration plant is never still, the period of mixing in its broadest sense may be stated as being the time from the addition of the coagulant until the water reaches the filters. As used in the literature on filtration, and as used in this article, it is intended to define that part of the plant where the coagulant is added and there the water is kept in motion at a velocity sufficiently great to prevent settling of the flocculated matter.

It should be evident that coagulation and flocculation will eventually take place in settling basins with very long periods of settling, even if there is no mixing basin, for there is a continuous though slow motion of the water in such basins. The formation of the flocculation is very slow in settling basins, and it is usually economy to make the flocculation complete in basins designed for that purpose. The mixing basin should be responsible for the flocculation, and the settling basin should be limited to the function of settling out the flocculated matter. If it takes 60 to 90 minutes mixing to produce a good flocculation during the worst conditions of the water, then the mixing basin should be designed for this time unless such periods are of very short duration and additional coagulant may be used more cheaply than providing a longer period of mixing.

The trouble with the mixing basin in many filtration plants is that they are warm weather mixing basins, and are not adequate for water at a temperature near the freezing point. As a result, many filtration plants are overtaxed in the colder months and are not capable of producing perfect water all the time. Why not give more consideration to cold weather conditions? A basin designed for the water at its minimum temperature certainly would not be inefficient for warmer water, though it may have considerably longer mixing time for the warm water than is necessary.

The value of prolonged mixing is to provide more rapid sedimentation of the flocculated matter. Where the water temperature goes below about 5° C., most filter beds will not handle very much flocculated matter without danger of some of it passing the beds. Usually it is desirable to settle to the extent that the flocculated turbidity is below about 10 during the colder months, and the writer believes it is desirable to settle to 5 or even less for most waters where the temperature goes nearly to the freezing point.

It is not possible to discuss the time of mixing without giving some consideration to settling, for the main purpose of the mixing basin other than to

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distribute the chemicals uniformly throughout the water is to prepare the water for the settling basins. The curves in Fig. 1 show the relation between the time of mixing and rate of settling at both 1° and 20° C. for turbidities of 10 and 100. Percentage of flocculated matter settled out may not be a very good method of expressing the results, for 50 per cent settling with a flocculated turbidity of 10 leaves no more flocculated matter in the water than 95 per cent settling for a turbidity of 100.

Long Periods of Mixing Give Best Settling Results.—If it is desirable to reduce the flocculated turbidity of a certain water at 1° C. to 5 within a period of 4 hours settling, it is shown that about 60 minutes mixing in a good mixing basin is necessary for the particular water on which the tests were made. This is based upon using the minimum quantity of coagulant necessary to clarify the water. No one should expect to get points that follow the curves exactly. They were drawn from a number of points obtained from plant results. The points varied widely, in fact, so widely as to make one hesitate to show the results by a curve. The curves are about an average of what is being accomplished in well operated plants. One reason for wide variations in settling results is that most filtration plants do not operate on the minimum coagulant necessary to produce clarification, but use a slight to considerable excess most of the time.

Fig. 2 shows the rate of settling for 5 and for 60 minutes mixing time. If a flocculated turbidity of 10 is desired, it is evident from the curves that a mixing time greater than 5 minutes is essential, unless there is a very long period of settling. The same remarks in regards to wide variations from the curves in Fig. 1 also hold for the curves in Fig. 2. The curves shown are about an average of what to expect when the water is near the freezing point. They also are based on the use of a coagulant only. Hard waters that are partially softened in the process by the production of a precipitate of calcium carbonate settle the flocculated turbidity much faster. The writer has found no difficulty in reducing the flocculated turbidity of a partially settled water, where lime was used for the softening, from 50 to 2 within an hour after a mixing period of about 60 minutes. Should the flocculated turbidity have been 500 it probably would have been reduced to this same low figure within approximately one hour.

It Is Economy to Use a Fairly Long Period of Mixing.—The writer can conceive of very few conditions where it would be economy to have a mixing period less than 30 minutes. In most instances it is economy to have a mixing time of from 45 to 60 minutes for aluminum sulfate, ferric chloride, and chlorinated iron; and from 60 to 90 minutes for ferrous sulfate and lime, and for softening processes where calcium carbonate is precipitated. About the only exception to the necessity for these long periods of mixing to produce good results is where an excess of coagulant is used for some purpose other than clarification. The writer has been told that one of our larger cities uses an excess of coagulant most of the time so as to get better bacterial removal. This is all right, but plants that care to use only the minimum coagulant should not use this plant as a guide for determining their mixing time.

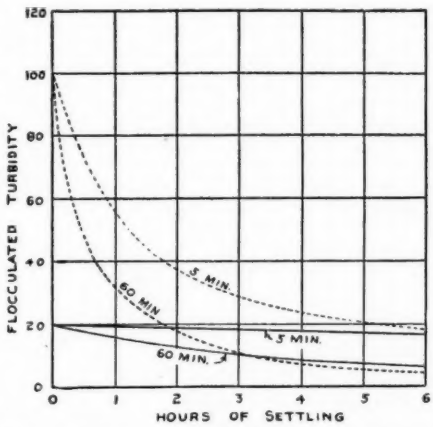


Fig. 2—Effect of Time of Mixing on Settling Rate

The writer has performed a number of laboratory experiments on varying the time of mixing. It is usually possible to bring about good flocculation in the laboratory with a stirring machine within 50 to 70 per cent of the time necessary to produce equal flocculation in a well designed plant mixing basin. The settling rate in beakers also is faster than in a plant settling basin. One hour in a beaker usually produces better clarification than 4 hours in a settling basin. Table I is typical of what one might expect for stirring experiments in the laboratory when the turbidity is very low and when the temperature is near 20° C. The raw water turbidity was 3.0, and when treated with 8 parts per million of aluminum sulfate the flocculated turbidity was 4.0.

Eight parts per million of aluminum sulfate was an excess of coagulant, but about what is being used in many filtration plants under similar conditions of turbidity and temperature. The minimum coagulant to clarify this water by filtration was 5 parts per million. Table II shows the settling results for the minimum coagulant.

Table I indicates that 20 minutes stirring with the laboratory stirrer would be about the economical time. This 20 minutes would be equal to about 30 to 35 minutes mixing in a plant mixing basin. If the water had been near the freezing point instead of room temperature it would have required a longer time to produce a flocculation that settled as rapidly as that for Table I, perhaps 50 to 60 minutes mixing in plant mixing basin would have been about the economical time. Table II indicates that with the minimum coagulant not much setting need be expected within 5 to 6 hours.

Table III gives the settling rate for various periods of stirring with a laboratory stirring machine when the raw water turbidity was 75.

Table III indicates the economical mixing time for a laboratory stirrer to produce a rapidly settling flocculation to be about 15 minutes when the turbidity is 75 and the temperature about 16° C. This would mean about 25 to 30 minutes in a plant mixing basin for the same conditions. With this same turbidity, and a temperature near the freezing point, the economical mixing time for a filtration plant would be about 35 to 45 minutes. Table III shows greater settling efficiencies than are shown by the curves in Fig. 1, but the curves are based on plant results. The laboratory tests were run in 2-liter beakers with a stirrer having two blades ½ in. wide and 1½ in. long. The stirrers were run at a velocity of approximately 1.0 ft. per second for the tip end of the blades. This seemed to impart nearly the same velocity to the water as the speed of the end of the blades.

Settling Rates Vary Widely in Filtration Plants.—Looking over the monthly report of a large filtration plant for the month of January when the water temperature was near the freezing point, the turbidity of the raw water averaged 8 and the settled water 2.5. The plant had a mixing time of about 40 minutes and a settling time of about 4 hours. This would give a point considerably off the curve shown in Fig. 1 for 40 minutes mixing, indicating the curve is not very accurate.

Table I—Settling Rates for Various Periods of Mixing

8.0 parts per million of aluminum sulfate used. Raw water turbidity, 3.0. Flocculated turbidity, 4.0.

Time Stirred in Minutes	Turbidity After Standing in Beakers 1 Hour	3 Hours
0	4.0	3.5
5	3.8	2.8
10	3.2	2.0
15	1.8	1.4
20	.7	.3
30	.4	.2
40	.2	.1

Table II—Settling Rates for Various Periods of Mixing When the Minimum Quantity of Coagulant Is Used

Raw water turbidity, 3.0. Flocculated turbidity, 3.5. 5.0 parts per million of coagulant used.

Time Stirred in Minutes	Turbidity After Standing in Beakers 1 Hour	18 Hours
5	3.5	1.3
10	3.0	1.1
15	2.5	1.0
20	2.2	1.0
30	1.8	.9
40	1.5	.8

Table III—Settling Rate for Various Periods of Mixing With Turbidity of 75

Water treated with 13 parts per million of aluminum sulfate. Flocculated turbidity, 76. Temperature, 16° C.

Time Stirred in Minutes	Turbidity After Standing in Beakers 30 Minutes	1 Hour	3 Hours
0	75.0	74.0	54.0
5	47.0	33.0	24.0
10	11.5	7.5	4.5
15	4.0	3.2	2.4
20	1.7	1.7	1.2
30	.7	.7	.6
40	.6	.5	.5

It is admitted that the curve is not accurate for some waters. In this particular case, 11 parts per million of aluminum sulfate were used to coagulate the water. Under most conditions 6 to 7 parts would have been enough, therefore the main cause for the rapid settling probably was due to the use of an excess of coagulant.

Very likely it was desirable to get good settling in this plant to prevent flocculated matter passing the filters. There is no criticism for using an excess of coagulant to produce better settling so as to produce a better filter effluent; it is the thing that should be done. This is one of the reasons why many plants will give results that vary widely from the curves shown in Figs. 1 and 2. In the particular instance mentioned the water may have contained a small amount of extremely finely divided particles that required a larger amount of coagulant than otherwise would have been necessary. The writer has treated water in which the average quantity of coagulant usually applied would give very good flocculation, but when the water was filtered it would have a turbidity of 0.5 to 1.0. To reduce this to the desired standard of 0.2, it would require from 25 to 75 per cent excess of coagulant. This excess, of course, gave a rapid settling flocculation. Just because a plant is using considerable excess of coagulant over what other plants for similar turbidities are using does not mean that the plant is inefficient, but in most instances it is.

Violence of Agitation.—There is every indication that a velocity of 1.0 to 1.3 ft. per second, now extensively used in mixing basin design, produces about the desired violence of agitation in baffled basins. The more rapid the velocity of water, up to a certain point, the quicker it will flocculate. It usually is economy to use velocities somewhere near the maximum which will allow good flocculation. It has not been possible to determine accurately the maximum stirring velocities of the laboratory stirrers that will produce the quickest settling flocculation. There are indications that it is near 1.0 to 1.3 ft. per second for the ends of the blades. Two feet per second is too high. When experiments were run using this speed for the stirrers the flocculated particles would form to a certain size and then get no larger. This size was much less than what is essential for rapid settling. One and one-half feet per second velocity for the ends of the blades did not seem to produce a flocculation that settled as quickly as 1.0 ft. for the particular water tested, but the results were so near there were practically no difference.

These experiments were made with aluminum sulfate. Other chemicals may give slightly different results. Another set of experiments indicated that there was no advantage in using higher velocities in the first part of the mixing, providing the last 10 to 15 minutes stirring was at a rate of 1 ft. per second or slightly less. In plant basins it may be found slightly advantageous to start the mixing with fairly violent agitation, but the advantage is so little it does not justify the expenditure of much additional force for the extra agitation. If a more violent agitation is given immediately after application of the coagulant, the writer would suggest that it be for a period not greater than 4 to 5 minutes, for it very likely has no advantage beyond this time.

With straight conduits and circular basins where there are no abrupt changes in the direction of flow, greater velocities probably are desirable. It is believed that 2 to 3 ft. per second may be used without detriment under such conditions, but in these cases it probably is economy to use velocities not in excess of 1.5 to 2.0 ft. per second.

Why Not Guess on the Safe Side?—If the matter of mixing time is largely a guess on the part of the designer, why not guess on the safe side and give the operator a plant that will enable him to produce good results under the worst conditions of the water? The writer would suggest that no filtration plant be designed with a mixing time less than 30 minutes, except under some very unusual condition where it has been demonstrated conclusively that a shorter period gave the more economical results.

Central Clearing House Aids Water Service

The Central Service Bureau established by the Hackensack Water Co. at its general offices in Weehawken, N. J., has become a huge clearing house for improving the operation and administration of the water supply system of Bergen and North Hudson Counties.

It now functions largely as an instrument of inspection and control, enabling the company organization to locate defects in service, to classify and to study these defects, and to take immediate steps to apply the appropriate remedy.

The bureau began operations on Oct. 1, 1928, with the expressed purpose of affording contact, direct and continuous, with consumers throughout the 24 hours of the day. Its development has been such that it now acts as an agency through which inter-departmental practice of the company may be carried on, and through which the municipal officials and the water users in the 51 towns and cities served by the company may immediately register their needs.

It is a receiving station to which any consumer at any hour of the day or night may report any untoward tendencies in the water system and be assured of speedy action. It is a repository of suggestions for social and technical betterment from individual citizens, from officials of cities, and from civic groups, as well as for the exchange of operating and administrative information among the departments of the company.

Co-ordination of public needs and company policy is thus accomplished. The company officials can at all times effectively check developments throughout the system, the operations of the Central Service Bureau quickly and clearly revealing strength or weakness at any point. In short, according to company officials, the bureau provides a method of vigilance by which standards of water service can be consistently improved. To it the entire staff of the company reports, and to it the public has ready access.

The second 5,000 reports received by the bureau have been recently tabulated by the company. Of these, 842 had to do with house pressure conditions, mostly originating in old plumbing; 700 with leaks in service pipes between curb lines, and 419 with leaks between curb lines and meters.

In response to requests, 595 curb boxes or curb valves were adjusted or repaired. Removal of check valves as a result of noises in house plumbing or other causes was requested by 553 customers.

The largest number of communications originated in localities where the majority of services have been installed for many years. From Union City came 570; from North Bergen, 473; from Englewood, 387; from West New York, 383; from Hackensack, 283; and from Fort Lee, 199.

The situations indicated by these communications, many of which were forwarded by municipal departments, were investigated by the company, and classified, the result being the creation of a vast and growing fund of knowledge on the operation of the water system.

When communications bearing upon service are received from any source they are recorded on special forms prepared for the purpose, and routed to the departments to which they relate. After investigation, they are reviewed by the company's hydraulic engineer, whose recommendations or suggestions are embodied in letters of reply. The bulk of the communications, by telephone or by letter, come directly to the Central Service Bureau in Weehawken. This practice the company encourages. Many customers report to the district offices, in charge of supervisors, who transmit the information to the Bureau.

Careful records are kept of how reports are investigated, of what action is taken thereon, and by whom, so that in time they will comprise the history of every service number. Daily happenings throughout the water company's territory are classified, making it possible, through observation extended over a long period, to identify fundamental differences common to a certain section. In this way, the requirements of special areas are anticipated.

Manipulation of pH in Water Purification

Experiences at Filtration Plant of the Department of Water, Light and Power of the City of Springfield, Illinois

By CHARLES H. SPAULDING

Chemist and Superintendent Water Purification, Springfield, Ill.

IN a water purification plant where lime is employed as at Springfield, the pH value of the water is manipulated up and down in order to obtain certain results. These results have a bearing on the softening of the water and also on coagulation, sterilization, and ultimate stabilization. The practical values derived from these ups and downs of pH vary under different circumstances, but an examination of one more actual case may show some of the limitations of the process and help to point the way to better application of the phenomena involved.

At the Springfield plant the raw water is treated with lime in a small dosing well just ahead of the mixing chamber. It is then stirred for 40 minutes by mechanical agitators in two parallel mixing chambers from which it flows to clarifiers and settling basins having combined detention periods of 5 hours and 40 minutes at the rated capacity of the plant. A 30-minute carbonation period follows the settling, and the water then goes to the filters.

Method of Feeding Lime. — The method of feeding the lime is unique in that there is a marked variation each hour in the concentration of the milk of lime flowing to the dosing well. This is due to the fact that the quick lime is weighed into the slaker in hourly batches while a constant stream of water enters the slaker and displaces the milk of lime.

The magnitude of the variation is disclosed by a chart from the recording thermometer which has been placed in the pipe carrying the lime suspension (Fig. 1). The purpose of the thermometer is to give a continuous record of lime dosage for the benefit of the operator as well as the superintendent. I believe it is a valuable aid in maintaining the efficiency of the plant. As indicated by the chart, the lime suspension is, roughly, twice as concentrated immediately following the addition of a charge of lime to the slaker than before the addition. When this pulsating treatment was begun it was found to lower the total hardness of the treated water 10 p.p.m. more than could be done with the same amount of lime fed at a uniform rate.

When treating to normal carbonates only, there is considerable fluctuation in the pH and alkalinity of the mixing chamber effluent which is smoothed out by the time the water has passed the clarifiers. When treating to 40 p.p.m. causticity there is but little fluctuation in the alkalinity and the pH varies only 0.1 from 10.7 to 10.8. This is because the magnesium acts as a buffer removing the extra hydroxyl ions furnished by the peaks of the lime dosage.

Recarbonation. — The recarbonation of the settled water is accomplished with stack gas from the boilers of the nearby pumping station and power plant. The carbonating equipment includes two scrubbers, one gravel filter, one blower, a distributing grid submerged in the carbonating chambers, a CO_2 recorder, and a gas meter. There is also a 2-in. discharge line leading to the filtered water conduit which can be used to reduce the pH of the filtered water. The cost of the equipment was $7,000, of which $4,500 was for the pipe contract.

The maintenance on the carbonating equipment was considerable at first, due principally to omission of the scrubber near the boilers. The compressor which is a rotary displacement blower, has not maintained its full capacity, but we do not find that this is a result of the character of the gas. During the past year the equipment has been operated with but little attention. The per cent of CO_2 in the gas is regulated by dilution valves admitting air as required to the suction of the compressor. The quantity applied is regulated by hourly tests of the carbonated water. The items of operating cost are power, $2.40 per day, and water $.77 per day, which together amount to 44 cents per million gallons.

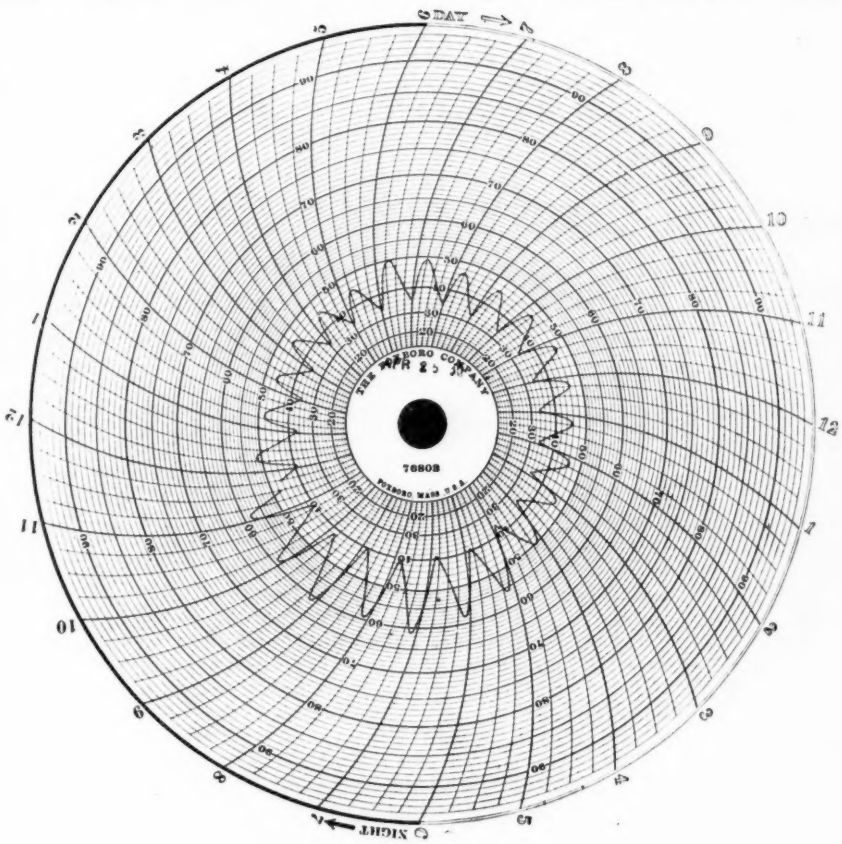


Fig. 1

The fuel used under the boilers from which this gas is taken is low grade bituminous screenings, containing 4 per cent to 5 per cent sulphur. Sulphur dioxide, however, is much more soluble than carbon dioxide, and the greater part is removed in the first scrubbing. There were predictions that chlorophenol tastes would be a problem if this gas were used. A few preliminary tests, however, showed that we had nothing to fear from phenols and the results have been entirely satisfactory in this respect. The soot and tarry compounds caused some trouble in handling the gas, and the single scrubber of the original installation was sup-

plemented by a second scrubber located close to the boilers. This materially helped matters, but the gas is still not as clean as could be desired, and various parts of the piping system require flushing-out every six months. Boiler operating conditions at present are far from ideal from the standpoint of clean smoke, but improvements are under way at the boiler plant which will permit better combustion and will probably remedy this situation, though it is not serious.

Effects of pH Values Compared.—A comparison of the effects of lower and higher pH values in the treated water can be made by an examination of the plant records for the years 1928 and 1929. In 1928 the settled water had a total alkalinity of 50 p.p.m., of which 1 p.p.m. was caustic and the balance normal carbonates. This water was filtered and the filtered water partially recarbonated in the filtered water conduit. The final effluent had a total alkalinity of 47, of which 28 p.p.m. were normal carbonates and the balance bicarbonate. In 1929 the settled water had a total alkalinity of 69 p.p.m., of which 35 p.p.m. were caustic and the balance normal carbonates. This water was carbonated before filtering to remove excess lime, and the final effluent averaged 35 p.p.m. total alkalinity, of which 28 p.p.m. were normal carbonates and the balance bicarbonate. Table No. I shows some results of these two treatments.

The record shows that the filtered water was 14 p.p.m. softer during 1929 than the previous year. The apparent lime cost per ton of hardness removed was $1.38 more in 1929 than the previous year; but due to the coagulating value of the extra magnesium hydroxide precipitate during 1929, a considerable cut was made in the amount of alum used, and this saving should be deducted from the softening cost. When this is done there is practically no difference in the per ton cost of hardness removed. During both years considerable hardness has been deposited on the filter sand. It has been found that when the sand grains accumulate a coating of scale equal to their own weight, filter efficiency begins to suffer appreciably, and it does not seem advisable to continue the process without replacing the sand. This means that one ton of sand is used in removing a ton of hardness from the water applied to the filters. The cost of filter sand delivered at the plant is $5.00 per ton. Allowing $1.00 per ton for handling in and out of the filters, brings the total cost of hardness removed in this way to $6.00 per ton, and lowers the average cost of all hardness removed to $10.56 per ton.

Table I

	1928	1929
Total hardness raw water, p.p.m.	248	230
Total hardness filtered water, p.p.m.	95	81
Total alkalinity raw water, p.p.m.	206	185
Total alkalinity filtered water, p.p.m.	47	35
Magnesium (as $CaCO_3$) raw water, p.p.m.	109	100
Magnesium (as $CaCO_3$) filtered water p.p.m.	70	50
Turbidity raw water	99	103
Lime used lb. per mil. gal.	1,386	1,461
Alum used lb. per mil. gal.	80	32

A comparison of the chemical costs of these two years is shown in Table II:

Table II

	1928	1929
Tons Hardness Removed by Lime Alone	1525	1451
Tons Hardness Removed on Filters	130	199
Total Tons Hardness Removed	1655	1650
Tons Lime Used	1794	1922
Tons Alum Used	104	42
Cost of Lime per ton, Hardness Removed	$ 11.00	$12.38
Cost of Lime corrected for Alum saved	.....	11.19
Cost of Sand per ton Hardness Removed	6.00	6.00
Cost of Lime and Sand per ton Hardness Removed	10.00	10.56

In spite of these figures it does not seem advisable to continue this sort of treatment. When settled water of pH 10.8 is recarbonated to 9.3, it is extremely unstable. It not only incrusts the sand but also the conduit and valves leading to the filters, so that in a few years these might become serious problems. Another problem which may be included among sequelae is magnesium silicate scale in hot water heaters.

Water of 30 to 30 p.p.m. alkalinity and pH 9.3 has shown no tendency to deposit calcium carbonate scale either in cold or hot water lines, but we have found in hot water systems a scale of which the following is a typical analysis.

Analysis of Silicate Scale

Loss on Drying	6.2
Loss on Ignition	17.0
Silica, SiO_2	35.1
Oxides, R_2O_3	3.64
Magnesium Oxide	37.5
Undetermined	.56

Water entering and leaving the heater from which this scale was collected showed the following changes through the heater.

Effect of Heater on Mineral Constituents

	Entering	Leaving
Alkalinity Total	32	28
Alkalinity to Phenolphthalein	9	28
Alkalinity to pH	9.3	9.1
Silica, SiO_2	13.2	7.8
Calcium Oxide, CaO	22.6	22.4
Magnesium Oxide, MgO	20.7	19.0

These analyses show that magnesium and silica are the important constituents in this case, and that calcium carbonate is out of the picture except, perhaps, as it affects the pH of the water.

The scale formed is soft, but it adheres sufficiently tight to effectively close hot water lines if not removed. Until we know more about this sort of scale, it seems advisable to use alum as a coagulant continuously and to keep the pH of the final effluent near 8.4.

The bacterial efficiency of the Springfield plant is based almost entirely on coagulation and chlorination. The line used plays an important part, but not as a sterilizer.

Acknowledgment.—The above is an abstract of a paper presented at the 50th annual convention of the American Water Works Association.

Garbage Collection and Disposal at Milwaukee, Wis.

The following note is abstracted from the 1929 report of the Common Council of Milwaukee, Wis.:

The city's present methods of handling its garbage dates from 1923 when a separate bureau of garbage collection and disposal was esbtablished and when the trailer system was inaugurated.

The city is divided into four sections, consisting of the east and north section, north central and west section, the south section, and the downtown commercial section. Three sections consist of eight tractor-truck units which are further subdivided into 32 trailer routes. A trailer route contains six districts contiguous to one another and of an area sufficiently large to constitute a day's work of 8 hours. These districts are numbered from one to six inclusive and designate the days of the week in which the teamster and his helper are to be working in their respective districts.

The fourth section consists of five "direct" routes and one commercial truck route. The "direct" routes are short, direct hauls adjacent to the incinerator which is located near the inner harbor entrance. One truck collects daily from the downtown hotels and restaurants in the commercial district, and also has assigned territory in newly annexed territory.

Only garbage originating in private homes is collected free of charge, while 20 ct. is charged for each can of commercial garbage of 20 gal. or less. Household garbage must be securely wrapped in strong paper, must contain only animal, fruit, or vegetable waste without liquids, and must be deposited in cans of an approved type.

The incinerator, built in 1910, contains four independent furnace units, each with a rated capacity of 75 tons of refuse per 24 hours, based on a mixture of 60 per cent garbage and 40 per cent ashes and rubbish. The present mix is 80 and 20. The ashes drawn from the grate are carried away in trailers and dumped at the lake front. This filling over a period of years helped in building enough new land for the present city airport. Plans for a new incinerator have been completed and funds are available.

The 46,782.3 tons of garbage collected during 1929 cost $5.26 per ton, or $0.44 per capita. In other words, the cost was 1 ct. a day for a family of five. A total of 62,135 tons of refuse, including garbage privately delivered and household ashes, was incinerated at a cost of $139,867.75. This incineration cost $2.25 per ton, as compared with $2.27 for 1928; the per capita cost was 25 ct. The net cost of operating the division—administration, collection and disposal—was $402,721.32, or 72 ct. per capita.

Water Treatment Works of Iola, Kan.

Some Details of New Filtration and Water Softening Plant Recently Installed

By M. P. HATCHER

Burns & McDonnell Engineering Co., Kansas City, Mo., and Los Angeles, Calif.

THE water supply of Iola, Kan., is obtained from the Neosho River. The present treatment at Iola includes only plain sedimentation and sterilization. The circulating water pumps on the power plant condensers discharge through the condensers to two settling basins of 2.5 and 3.5-million gallons capacity. These basins are operated on a fill and draw plan. Settled water is delivered by motor-driven centrifugal pumps in the power plant from these basins to the distribution system. No distribution system storage is at present available. Chlorine is applied to the suction of the high service pumps.

The extent of pollution in the Neosho River and the quantity of suspended matter transported point readily to filtration as a part of any adequate plan of treatment. A consideration of the mineral constituents made it apparent that lime softening could be added to advantage.

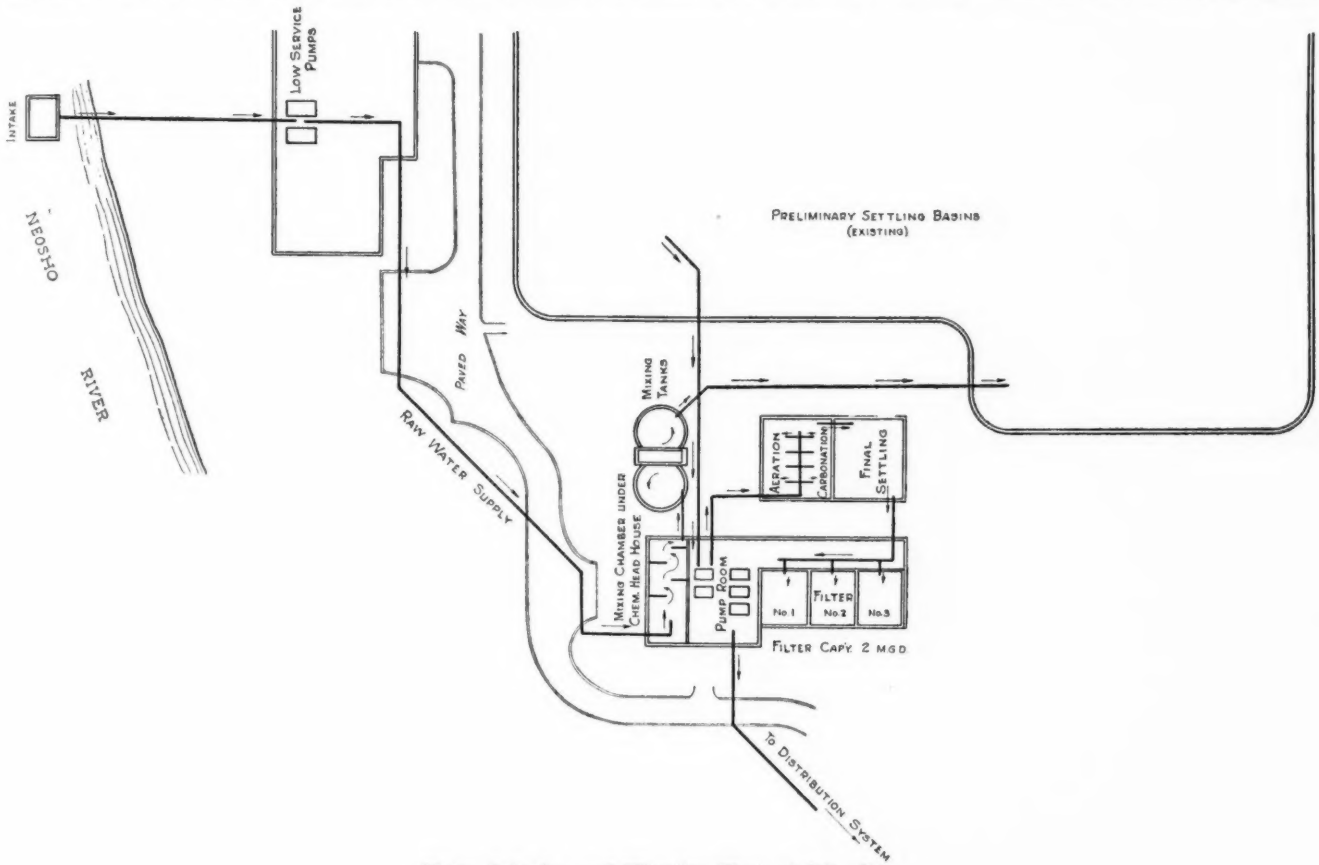
Character of Supply.—The lack of continuous records makes it difficult to picture accurately the character of dissolved solids in the water. Hardness varies from about 100 to 500 parts per million, with an average of 225 to 250 parts. Most samples show this hardness to be due largely to calcium in the carbonate form, which generally represents from 65 per cent to 75 per cent of the total hardness. Magnesium is usually lower than 20 parts per million. During low flow periods the effect of oil field pollution is indicated by a chloride content as high as 500 to 700 parts per million. Most of the year, however, the chloride content is less than 400 parts.

It was necessary in the design of the filtration and softening plant to keep the cost at an absolute minimum, consistent with good practice, and to confine the structures to limited areas available near the existing basins. Two million gallons per day was adopted as the nominal capacity of the new plant, with provisions for extension of the various plant facilities. Space for high service pumping equipment was provided in the new plant in order to centralize operation and provide for increased capacity not possible in the present location.

New Treatment Plant.—The new treatment may be best described by reference to the various facilities in their proper sequence: Raw water will be delivered by the present low service pumps in the power plant through the plant turbine condensers to the mixing chamber below the chemical application room. Lime from dry feed machine and lime slaker is applied at the entrance to this chamber. The mixing chamber is the usual under-and-over baffled unit having a retention period of about nine minutes and a velocity of 0.8 ft. per second. High velocities are maintained in this unit to preclude the possibility of deposition of suspended matter.

After this preliminary mixing operation the lime treated water passes to the reaction tanks. Reaction is obtained by an adaptation of the spiral inward flow principle, using a low-head drainage-type centrifugal pump to maintain circulation in two circular tanks of the same size and shape. These reaction tanks have a nominal retention period of about 30 minutes.

The discharge from the reaction tanks passes through an 18 in. steel pipe through sluice gates to either or both of the existing basins. The total ca-



Water Softening and Filtration Plant of Iola, Kan.

pacity of these basins represent a retention period of about three days. While the average retention period will no doubt be reduced below this time, it is evident that excellent lime reaction and sludge removal should be obtained.

Water Softening. — Auxiliary low service pumps in the new pump room deliver the water from these settling basins to the aerator and carbonating basin. Aeration is obtained through the use of the Sacramento spray nozzle, the discharge falling into the carbonation chamber beneath. Carbon dioxide from a natural gas generating plant in the chemical head house will be distributed through a grid system on the floor of the carbonation chamber. A 30-minute retention period is provided in this unit.

The carbonation basin is followed by an alum reaction chamber wherein a hydrate floc is produced to provide a proper mat on the filters which follow. The alum is applied by dry feed machine in the head house to the suction of the auxiliary low service pumps. The reaction proceeds through the carbonating chamber—the resulting floc being conveyed by controlled velocities through the alum reaction chamber to the filters. Some of the floc (depending on the character and amount of suspended matter in the water) will settle in this basin, thus reducing the filter load, but the major portion will be carried to the filter bed to form the hydrate mat so necessary to proper filtration.

Filtration Plant.—Filters are provided in three units each, capable of filtering about 667,000 gal. per day. Filtered water passes to the storage reservoirs below the filters, pump room and secondary basins. A total of 215,000 gal. of filtered water storage is provided.

The arrangement of filtered water reservoirs in three units offers greater flexibility in operation and better circulation than is generally obtainable in this unit of a treatment plant.

The filtered water reservoir is arranged in three separate units, all interconnected. In normal operation the filter effluent will dicharge to the space below the filters, passing through the reservoir below the secondary basins, thence to the reservoir below the pump room. Chlorine is applied at the entrance to the last reservoir.

While the filtered water storage capacity is sufficient for normal requirements, it may not be sufficient to meet the requirements of a 6 to 10-hour fire. For such extreme emergencies a provision is made whereby the upper 5 or 6 ft. in the primary basins will flow by gravity past the point of chlorination to the filtered water reservoir below the pump room floor, being delivered then by the high service pumps to the distribution system.

Quick lime will be used for softening, as mentioned before. The lime will be purchased in bulk, delivered to the railroad siding on the plant site, and hauled by truck to the unloading dock of the chemical head house. The lime will be unloaded to a hopper whence it will be carried by a bucket elevator to the steel storage bin above, with a capacity of about 75,000 lb. or 30 to 45 days' supply. The lime will feed by gravity to the lime dry feed machine, thence to lime slaker, then to the point of application in the mixing chamber.

Alum will be delivered in 200 pound sacks, which will be trucked to the loading dock and carried by the bucket elevator to a steel alum storage bin above. The bin has a capacity of about 20,000 lb. or 40 to 60 days' supply. The alum will discharge by gravity to the dry feed machine, thence to the suction lines on the auxiliary low service pumps.

Laboratory and office space is provided on the floor over the pump room. Sufficient laboratory equipment will be purchased and installed to provide control of softening operations.

A steel storage tank of 150,000 gallon capacity has been purchased to equalize pumpage rate and head. The tank is furnished and erected by the Pittsburgh-Des Moines Steel Company, Des Moines, Iowa.

The general contract for buildings and structures has been let to Fry Brothers, Iola, Kan. Pumps will be furnished by the De Laval Steam Turbine Company, and electric equipment by General Electric Co. Filter equipment will be furnished by E. W. Bacharach & Co., and chemical feeding equipment by the Omega Machine Company, both of Kansas City, Mo.

Plans and specifications were prepared by Burns & McDonnell Engineering Company, Kansas City, Mo.

Acknowledgement.—The foregoing is a paper presented before the Kansas Water Works Association.

100 Year Rainfall Records in New England

The June issue of the Journal of the New England Water Works Association contains 192 pages of rainfall tables, the records covering the New England states, eastern New York and south eastern Canada. The paper was prepared by X. H. Goodenough, Chief Engineer, Massachusetts Department of Public Health. In the introduction he gives the following information regarding some long time rainfall records:

Records of rainfall for more than 100 years are now available at four places in New England, all of which are in eastern Massachusetts, viz., at New Bedford, beginning in 1814; at Boston, beginning in 1818; at Waltham, beginning in 1825; and at Lowell, beginning in 1826. The rainfall observations at these places have been continuous at some point in the municipality indicated since they were first established, and though there have been changes in the location of the rain gauges these changes do not appear to be such as to be likely to cause a material variation in the amount and distribution of the precipitation in the localities indicated.

An inspection of the tables for the four stations mentioned above indicates that the rainfall for many years in the beginning up to about the year 1850 and again in the years following 1903 was considerably lower on the average than in the middle years of the 100-year period. This variation is shown in Table I in which the average rainfall is presented at each of the four stations for periods of approximately 25 years, beginning in 1826.

From this table it appears that in the period from 1850 to 1876 and again in the period from 1877 to 1903 the precipitation was considerably higher at all of the stations with the exception of New Bedford than in the earlier period from 1826 to 1849, or in the period from 1904 to the present time.

While aside from the records at the places included in the above table there are no records which cover a period of 100 years, there are a number which have been continuous for a period of more than 75 years in the same localities, viz., at Providence, R. I.; Amherst, Cambridge and Springfield, Mass.; Gardiner, Me.; and Burlington, Vt. There is also a long record at Lynnfield, Mass., beginning in 1842, by combining which with observations at Reading and Winchester, which are in the same general neighborhood—the Reading station being about 3½ miles northwest and Winchester about 7 miles southwest of Lynnfield—it is practicable to compile a continuous record for that general neighborhood for a period of 88 years.

The comparative average rainfall at these stations for the last three of the periods shown in Table 1 are given in Table II.

Table II shows results for the period since 1850 quite similar to those for the same periods in Table I.

Table I—Average Annual Rainfall by Periods (Inches)

Period	New Bedford, Mass.	Boston, Mass.	Waltham, Mass.	Lowell, Mass.
1826-1849—24 years	47.21	42.00	41.13	39.45
1850-1876—27 years	46.73	53.18	43.00	45.73
1877-1903—27 years	47.79	45.52	44.40	45.95
1904-1929—26 years	44.23	40.32	40.24	41.43
1826-1929—104 years	46.49	45.40	42.24	43.26

Table II—Average Annual Rainfall by Periods (Inches)

Period	Providence, R. I.	Amherst, Mass.	Cambridge, Mass.	Springfield, Mass.	Gardiner, Me.	Burlington, Vt.	Lynnfield, Mass.
1850-1876—27 years	46.55	45.82	47.20	46.04	45.33	33.20	47.29
1877-1903—27 years	48.56	45.37	43.31	46.52	44.30	32.41	43.80
1904-1929—26 years	44.63	41.75	38.03	38.76	40.90	31.04	39.88
1850-1929—80 years	44.60	44.35	42.91	43.84	43.54	32.23	42.71

Maintaining Chemical Balance to Resist Corrosion

How Water May Be Treated So That It Will Deposit an Impervious Film to Prevent Corrosion

By CHARLES P. HOOVER

Chemist in Charge, Water Softening and Purification Works, Columbus, Ohio

A FEW commonly used remedies for preventing corrosion are as follows:

(1) Boiler feed water is usually preheated in open feed heaters in order to drive the oxygen out of the water. The elimination of the oxygen minimizes corrosion.

(2) It has already been stated that the lower the pH, the higher will be the amount of iron that will be dissolved in it. The reverse of this is also true. The higher the pH, the smaller will be the amount of iron water that will be dissolved. It is therefore good practice to treat water that is to be used for boiler feed purposes with from 30 to 50 parts per million of alkalies in excess of that required to soften it.

(3) Corrosive water has been made non-corrosive by passing it through a bed of scrap iron or iron filings. In other words, instead of letting the water damage valuable pipes, heating coils or boilers, it spends its energy or aggressiveness for dissolving iron on scrap material.

(4) It is common practice to coat the interior of pipes with zinc, cement, tar or some other manufactured product.

(5) Speller [1] states that an application of 20 parts per million of alkalinity by the addition of sodium silicate (15.6 lb. of 40° Baume sodium silicate containing 6 per cent Na_2O per 1,000 cu. ft. of water) is sufficient to almost completely stop the action of water on iron.

(6) Corrosion can be prevented by adjusting the chemical balance of the water. Water may be so treated that it will deposit an impervious film on the inside of a pipe or on iron surfaces with which it comes in contact. This film will prevent the water from coming in direct contact with the iron and will thus prevent corrosion.

How to Build Up a Film with Calcium Carbonate.—It is this phase of the problem that we now wish to emphasize. The film can be built up with calcium carbonate. To build up a deposit with calcium carbonate, the water must be saturated or at least almost saturated with calcium carbonate. Water that is super-saturated with calcium carbonate will quickly deposit a coating or film on the inside of the pipe. Water that is almost saturated, and this applies to numerous natural supplies, will also deposit a protective coating because in the process of corrosion, CO_2 is taken from the water.[1] The solubilty of calcium carbonate in natural water depends on the CO_2 content, therefore, if some of the CO_2 is absorbed, the nearly saturated water becomes saturated or perhaps supersaturated. As soon as this point is reached, deposition of calcium carbonate starts and the corroding iron becomes coated with a protective film of calcium carbonate. Water that is under-saturated with calcium carbonate, will dissolve any calcium carbonate film already formed. How is it to be known whether or not water is saturated, super-saturated or under-saturated with calcium carbonate?

Determining Saturation Conditions of Water.—The test to determine this is a very simple one and was outlined to the writer by Mr. John R. Baylis.[2] To carry out the test in a practical way where extreme accuracy is not required, proceed as follows: Divide the sample of water to be tested into two parts. Determine the alkalinity to methyl orange on sample No. 1 and record the results obtained. To sample No. 2 (say to 150 c.c.) add a considerable excess of calcium carbonate, stir a few minutes, settle, filter and determine the methyl-orange alkalinity. If the alkalinity of sample No. 2 is higher than the alkalinity of sample No. 1, the result shows that the water is under-saturated because calcium carbonate has been dissolved. In other words, the results show that the water tested is capable of dissolving and holding in solution an additional amount of calcium carbonate. Such water would dissolve a protective calcium carbonate coating. If the alkalinity is exactly the same on both samples, this would indicate that the water is neutral to calcium carbonate, that is it will neither dissolve nor deposit calcium carbonate.

If on the other hand, the alkalinity of sample No. 2 is lower than the alkalinity of sample No. 1, then the sample is super-saturated with calcium carbonate and will drop a deposit when the water comes in contact with iron surfaces. I am not prepared to state the theory as to why the addition of excess calcium carbonate throws calcium carbonate out of solution. It may be reaction induced by contact. The finely divided calcium carbonate furnishes numerous or multiple contact points.[3] What is the saturation point, or, in other words, how much calcium carbonate will water hold in solution? A curve by Baylis [4] shows that the approximate solubility equilibrium of calcium carbonate varies from about 15 parts per million to over 350 parts per million, between the pH value 6.8 and 9.3. At a pH value of 9.0, for instance, water is saturated with calcium carbonate when it contains only about 20 parts per million, whereas 350 parts per million is held in solution, if the pH is, for instance, say 6.8.

Corrective Treatment.—In using the chemical balance process to build up a protective coating, care must be taken not to continue the building up process too long because if it is continued too long, pipes will become clogged. This is exactly what has happened in many municipalities having lime soda-ash water softening plant. The water produced being super-saturated, resulted in too much deposit in the pipe lines, meters and heating coils and a means for preventing this had to be found. A practical corrective treatment process has been perfected and the trouble has not been entirely overcome by the process of recarbonation, that is, by adding carbon-dioxide gas to the water. Protective films built up by calcium carbonate will not last very long if the water brought in contact with them is under-saturated, because the under-saturated water will dissolve them. If water is super-saturated and forms too much deposit, this condition can be corrected as already explained by the additon of carbon-dioxide. The next question we have to consider then is, how can the water be corrected if it is under-saturated with calcium carbonate? The first thing to do is to determine the calcium carbonate content of the water. If it is found that the calcium carbonate content of the water is, say, something less than 20 parts per million, then it is necessary, if corrosion is to be prevented, to build up the calcium carbonate content. This can be accomplished by adding lime to the water, or if the water already contains some calcium sulphate, soda-ash can be added and the results will be satisfactory, because soda-ash reacts with calcium sulphate to form calcium carbonate, or it may be convenient to build up the calcium carbonate content by adding some hard water.

After the calcium carbonate content

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(1) Recent Developments in Water Treatment by Baylis, 33rd Report American Society for Municipal Improvements.

(2) Chief Filtration Chemist, Bureau of Engineering, Chicago, Ill., private communication.

(3) The term "multiple contact points" has been suggested by A. E. Kimberley.

(4) Industrial and Engineering Chemistry, July, 1927.

is known, the next thing to do is to build up the pH value if necessary. The most satisfactory way in which to build up the pH seems to be by the use of soda-ash. It has been our experience in working with soft water, that if enough soda-ash is added to give the water a distinct deep color to phenolphthalein, satisfactory results will usually be obtained. After the calcium carbonate and pH adjustments have been made, it is easy to determine whether or not the water is saturated, super-saturated or under-saturated by making the calcium carbonate test that has already been described.

This method was first used successfully to prevent corrosion in Baltimore.(4) I personally have had occasion to use it during the past year on an elaborate iron pipe cooling system. In this case, the cooling water is softened to about 25 parts per million, then enough soda-ash is added to give the water a distinct phenolphthalein alkalinity. Each day the water is tested for chemical balance. If the water is found to be under-saturated, additional soda-ash is added. On the other hand, if the water is super-saturated, the carbon-dioxide treatment is increased.

The tests are so easily and so quickly made that any operator should be able to determine without difficulty whether or not the water produced at his plant is in chemical balance or equilibrium and to predict the results to be expected in the distribution system.

Acknowledgment.—The above is an abstract of a paper presented at the 8th annual Three Day School at the University of Kansas and 5th annual meeting of the Kansas Water Works Association.

The National Hydraulic Research Laboratory

The American Engineering Council has announced the appointment of six representatives of the civilian engineering profession to serve on an Advisory Committee which under Dr. George K. Burgess, Director of the U. S. Bureau of Standards, will plan the design and equipment of the national hydraulic research laboratory recently authorized by Congress.

Two of the members chosen, John R. Freeman of Providence, R. I., internationally known authority on hydraulics, and William B. Gregory, professor of experimental engineering in Tulane University, will, it is also announced, spend several months studying the principal hydraulic laboratories of Europe, particularly those of Berlin, Munich, and Zurich.

Mr. Freeman, who is president of the Manufacturers Mutual Fire Insurance Co., and a past president of both the American Society of Civil Engineers and the American Society of Mechanical Engineers, has prepared tentative plans for the new Laboratory, which will be established in the Bureau of Standards, Washington, at an initial cost of $350,000. The building will be completed in about a year, and the laboratory will begin to function in two years.

It will be especially arranged for investigating the physical laws which define the motion of water, and for studying, by means of models and other special equipment, engineering problems arising in connection with measurement, control and disposition of large quantities of water, and the utilization of water for irrigation and power purposes.

Other engineering members of the Advisory Committee, which will at once begin consideration of the plans submitted by Mr. Freeman, are: Sherman M. Woodward, professor of mechanics and hydraulics in the University of Iowa; Lewis F. Moody, consulting engineer of Cramp-Morris Industrials, Inc., Philadelphia; Ely C. Hutchinson, editor of "Power," New York; Blake R. Van Leer, assistant secretary of the American Engineering Council, Washington.

On the Committee also are the following representatives of Government departments: J. P. Dean, office of Chief of Engineers, War Department; S. H. McCrory, Chief of the Division of Agricultural Engineering, U. S. Bureau of Public Roads, Department of Agriculture; N. C. Grover, Chief Hydraulic Engineer for U. S. Geological Survey, Department of the Interior; E. W. Lane of the Reclamation Bureau, Department of the Interior, Denver, Colo.

The laboratory will determine fundamental data useful in hydraulic research and engineering, including laboratory research relating to the behavior and control of river and harbor waters, the study of hydraulic structures and water flow, and the development and testing of hydraulic instruments and accessories.

Scores of problems already await study in the new Laboratory. Many require special equipment the cost of which is prohibitive for the individual manufacturer. These problems include phenomena involved in flood control and in the design of structures for Boulder Dam. Hydroelectric power companies, it is said, will be benefited by additional data relating to the design of trash racks, ground sluices, deflecting walls, intakes, spillways, etc.

There is now being conducted at the Bureau of Standards an investigation of flow in plumbing stacks and drains which is financed in part by the plumbing industry. Many millions of dollars are spent yearly in the United States for plumbing, but as yet only a small amount of scientific work has been done in establishing the design of plumbing systems, particularly for large buildings, on a solid basis. The present investigation is seriously hampered by lack of equipment which a national hydraulic laboratory would supply.

In number and extent of the problems to be considered the Laboratory, according to engineers, will surpass any in Europe. Through Mr. Freeman, data on researches in hydraulics both in America and abroad have been compiled. Among the foreign cities which have laboratories are Darmstadt, Dresden, Stockholm, Graz, Charlottenberg, Berlin, Wilhelmshafen, Braunschweig, Karlsruhe, Vienna, Danzig, Brunn, Munich, and Leningrad.

City Held Liable for Sewage Flooding Basement

The city of Tacoma, Wash., was held liable for damage resulting from sewage being forced back on to private property because of an obstructed or inadequate sewer in a decision handed down April 9, 1930, by the Washington Supreme Court (Boyer, et ux. v. City of Tacoma, 286 P. 659). "Public Health Reports," June 6, 1930, comments on the decision as follows:

The plaintiffs' property was connected with a sewer, which connection was required by the defendant city under the terms of a city ordinance. The connection conformed to the ordinance and was approved by the city's inspectors. Either because of some obstruction in, or the overtaxing of, the sewer, the sewage was forced back through the drainpipes of the plaintiffs into their basement. The sewer had been installed approximately 20 years before the flooding of the plaintiffs' premises and, when installed, it was undoubtedly of ample size. However, by reason of the growth of the territory served, it had become inadequate. No extraordinary storm conditions existed at the times when the premises were flooded.

An action was brought against the city and plaintiffs lost in the trial court. On appeal the supreme court stated the question as follows:

> Is the city liable under circumstances such as these for sewage discharged on plaintiffs' property, they having been compelled by ordinance to connect with the sewer, the connection having been made in the manner approved by the city, and there being no negligence of any kind on their part?

The appellate court held that there was liability on the city's part, saying:

> "* * * The theory of all of the cases which we have examined which hold the city liable under circumstances such as we have outlined above seems to be that the property owner is required to connect with the sewer; that he is not permitted to dispose of his sewage in any other way than the one way provided by the city; that he has no power or authority to remove the cause, or to in any way remedy the defect from which his injury arises; that the city alone has the power and the means to remedy the defective sewer or to replace an inadequate sewer; that no person should be required to suffer an injury caused by an agency over which he has no control and over which the city has absolute control; and that if an injury is inflicted by such an agency, he should be properly compensated therefor. We think this is the better rule and is well supported by both reason and authority."

Customer Accounting in a Water Department

An Interesting Description of the System Employed by the Department of Water Supply of the City of Detroit, Mich.

By HAL F. SMITH

Head Water Consumers Clerk, Department of Water Supply, Detroit, Mich.

THE Customers Accounts Division is divided into three bureaus, the Assessment Bureau, Customers Accounts Bureau, and the Collection Bureau. The work of these bureaus is so closely related that it is difficult to draw a definite line between them. For that reason, only by a sincere spirit of cooperation can a high standard of efficiency be maintained. Fortunately that spirit exists. A clear picture of any customer accounting plan would be incomplete without a description of the meter reading methods, but as that has been described, I shall not repeat.

City 99.5 per Cent Metered.—We have approximately 251,000 active revenue accounts 99.5 per cent metered. Meters are read and billed quarterly under the cycle billing plan. The rate is a three step sliding scale structure with a minimum charge and a service charge based upon the size of the meter. Each account is billed for indicated consumption and for service charge, these charges being combined and billed as one item.

Consumers meters are owned and maintained by the department. No charge to the customer for service to the meter is made, except where it is wilfully damaged by him or through his neglect, such as failing to provide against freezing or in allowing hot water to back into it. These exceptions are, however, numerous and are mentioned at this time because it creates one of our problems.

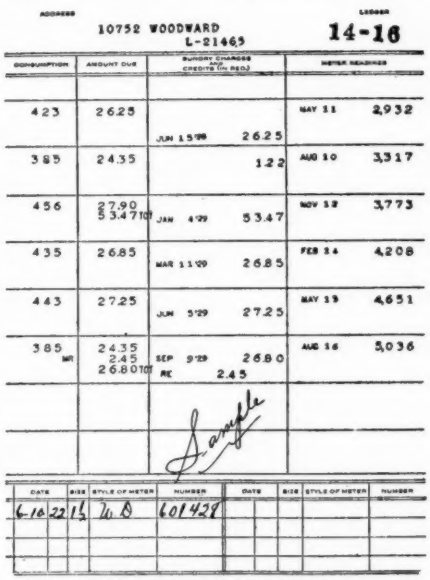
Combination Bill and Ledger Plan.—We are operating under the so-called combination bill and ledger plan of customer accounting, using individual ledger cards. The three major forms are the ledger card (Fig. 1), the bill (Fig. 2) and the proof sheet (Fig. 3), sometimes called the abstract sheet.

Both sides of the ledger card are identically ruled, making possible a four-year continuous record. In the space at the top are shown lot number, house number, street, mailing list number, and ledger number. The headings at the top of the vertical columns indicate their use. Each space set off by horizontal lines is for one billing period, which is identical with our balancing period. It is absolutely essential for balancing purposes that each entry made to the card be made in the proper space, as most entries are not dated. The space at the bottom of the card is ruled for the meter record.

The bill form is self explanatory. You will note that current rates are shown in the net amount only, and that the bill carries the notice that a 5 per cent penalty charge will be added after the indicated due date.

The abstract sheet is ruled to receive carbon impressions of the bill. The purpose of this important form will be later described.

Cycle Billing.—For the benefit of those who did not hear the paper on meter reading, the city is divided into



ADDRESS 10752 WOODWARD L-21463 LEDGER 14-16

CONSUMPTION	AMOUNT DUE	SUNDRY CHARGES CREDITS (in RED)	METER READINGS
423	26.25	JUN 15'29 26.25	MAY 11 2,932
385	24.35	1.22	AUG 10 3,317
456	27.90 53.47 CR	JAN 4'29 53.47	NOV 12 3,773
435	26.85	MAR 11'29 26.85	FEB 14 4,208
443	27.25	JUN 5'29 27.25	MAY 13 4,651
385 MR	24.35 2.45 26.80 CR	SEP 9'29 26.80 RE 2.45	AUG 16 5,036

DATE	SIZE	STYLE OF METER	NUMBER	DATE	SIZE	STYLE OF METER	NUMBER
6-16-22	1½	W D	601428				

Fig. 1.—The Ledger Card

three zones, each zone into twelve districts, and each district into routes. Each route contains a sufficient number of accounts to represent one day's work for a reader; they average 165 accounts. The reading unit is permanent, and is used as our balancing unit.

A moment's consideration of the above described division of the city will make clear the principle of cycle billing. Remember that each account is billed every three months. We have three zones. Therefore, one zone must be billed each month. Each zone contains twelve districts, and as the twelve districts must be completed in a month, each district must be completed in approximately two days. That is, each operation in each district must be completed in two days, whether it be reading, billing, collecting, balancing, or any of the other operations, if schedule is to be maintained. It is thus seen that every operation is a continuous one, thereby eliminating peak loads and making an even flow of work, not only possible, but absolutely essential.

Meter reading sheets are arranged in the order found to be most suitable for reading. They are locked into a binder, making this order permanent. Ledger cards and addressograph plates are filed in identical order of the reading book, thus eliminating any sorting at the time of billing. Ledger cards are filed in a room used exclusively for that purpose and may be withdrawn on requisition only. This practice has almost entirely eliminated the lost or misfiled card.

Mechanical Devices.—Every operation which, in our opinion, can be done practically by machinery is done by machinery. With the present wide range of highly efficient bookkeeping and calculating devices, there is very little need for long methods or mental calculations. With the exception of a battery of comptometers, we are entirely equipped with Burrough's machines, using their public utility machines for billing, their cash posting machines, and their various type adding machines.

Mailing List Plan.—While this general discussion is on, it might be well to describe our mailing list plan. All bills are delivered by our own force, directly to the premises served, except when requested otherwise by the owner. Approximately 30,000 owners have requested otherwise, that is, they have requested their bills for their properties be mailed either to themselves, to a certain real estate management company, or to a trust company. Out of our total of 251,100 accounts, the bills for approximately 75,000 are mailed in accordance with the owner's instructions. This volume demands a carefully thought out system in order to give the customer the kind of service he expects and deserves and yet hold to reasonable costs.

Our plan is this: Every owner, desiring this service, lists his property, giving the name and address to which the bills are to be mailed. A list number is then assigned and this number is applied to each ledger card affected, and to the corresponding addressograph plates. Then an addressograph plate is made carrying the mailing address and the list number and filed numerically by list number. From this plate two index cards are printed, one filed alphabetically by name and the other numerically by list number. Since the list number has been applied to the bill addressograph plate, each bill will carry its proper list number. The last operation, before turning the completed bills over to the Assessment Bureau

for delivery, is to pull all bills bearing a list number. These are then sorted into numerical order by list numbers, thus throwing all of a like number together. This sorting, completed, they are sent to the Addressograph Department, where the corresponding mailing plates are pulled, and with them envelopes are addressed. The envelopes will also bear the list number and will be in the same order as the bills. It is then but an operation of putting bills bearing a certain list number into the envelopes bearing the same number. Special sorting equipment and an electric envelope sealer are used.

Opening Consumers Accounts.—Consumers accounts are opened upon receipt of the meter installation report, at which time an addressograph plate is made and applied to a ledger card, upon which is entered the meter installation record. The card is then regularly filed in readiness for the initial billing.

Sundry debits are posted by machine to the ledger card prior to the billing date. Our sundry debits consist of meter repair charges, penalty charges, refunds, and debit transfers. All items posted to the card are immediately reported to the control keeper for entry to the control ledger.

Meter repair charge slips are received daily from the meter shop. They are indexed as to ledger number and sorted to districts. Total charges for each district are ascertained and entered to a memorandum ledger. These slips are then filed by districts. The day before District 11, for instance, is to be billed, all charge slips for that district are turned over to the debit poster, together with the corresponding ledger cards. Each item as posted to the card is transferred to a proof sheet by use of a duplicate carbon roll. At the end of each control unit, a transfer total is taken, and at the end of a district, a grand total. The grand total must agree with the above mentioned memorandum ledger. The proof sheet, showing totals charged to each control unit, is turned over to the control keeper.

Billing Work. — Burroughs public utility machines are used in our billing work. As most of you know, this machine types the bill, ledger card, and abstract sheet at one operation; the card and bill receiving original impressions, the abstract sheet being a carbon copy of the bill. The machine is so constructed that there is a mechanical assurance that certain operations are properly performed. It is equipped with a lock that prevents a change in the set-up during an automatic repeat print operation, thus assuring that the charges shown on the bill are identical with those on the cashier's stub. Another check that the machine makes is the verification of the meter reader's subtraction. The operator follows the reader's figures. If the billed consumption does not represent the difference between present and previous readings, the machine will automatically indicate the error on the ledger card.

Billing assignments are made by reading books, which is equivalent to our control unit. The operator receives the reading book, addressed bill forms, and corresponding ledger cards, all of which are in the same order. She first puts in the present and previous dates and readings, then consumption, followed by the rate charge, which she calculates either mentally or by reference to a rate chart. The next step is to put in any unpaid balance as arrears, followed by the posting of sundry debits, if any, and then to show the total charge, which is, of course, a machine operation. Our standard production rate is set at 800 bills per day per operator. Actual production is running very close to this figure.

Bills are proven for accuracy in the internal audit and control division of the Bureau by means of balancing the proof sheet. A detailed description of this operation would be too lengthy and too hard to follow, without having a sheet before you, but it may be said, in a general way, that the proof rests in balancing the amount obtained by applying the rate to the total rate revenue of the sheet. This necessitates, of course, grouping water sold at the various steps, grouping the various service charges, and making corrections for certain rate peculiarities. Any one interested may refer to the display board where a balanced proof sheet clearly illustrates this operation. Any bills found to be in error are sent back to the billing division for correction. The balanced proof sheet not only certifies to the accuracy of the billing, but also supplies our trial balance, revenue distribution, and serves as the basis of all our statistical data.

Posting Cash.—It is the practice in some highly organized and very efficient utilities to hold up the posting of cash to customers accounts until after due date, thereby simplifying this work, and, of course, reducing costs. We tried this and distinctly did not like it. Water accounts in Detroit are not accounts with certain individuals, but with legally described pieces of property. Either the tenant, owner, or agent may pay the bill. Some confusion naturally results, causing considerable inquiries as to whether a certain bill is paid. These inquiries are usually received before due date. We want to be able to reply that the bill is paid or unpaid, rather than to report that the bill is unpaid, unless paid within the last ten days, in which case it would not show on the ledger.

A practice has been adopted, therefore, and rigidly maintained, of posting all cash received, on the following day. Bills are paid in person at the main office, by mail to the main office, and to banks and their branches throughout the city. In order to post cash the day following its receipt, it is necessary to sort stubs and pull ledger cards immediately following the close of the day's business, so as to have them ready for posting the following morning. A night force consisting of one senior clerk and four juniors do this work. They also run a tape of the stubs, taking a transfer total at the end of each control unit, and a grand total which should agree with the cashier's reported total. Ledger cards are pulled for posting, only from the inactive districts; the active districts

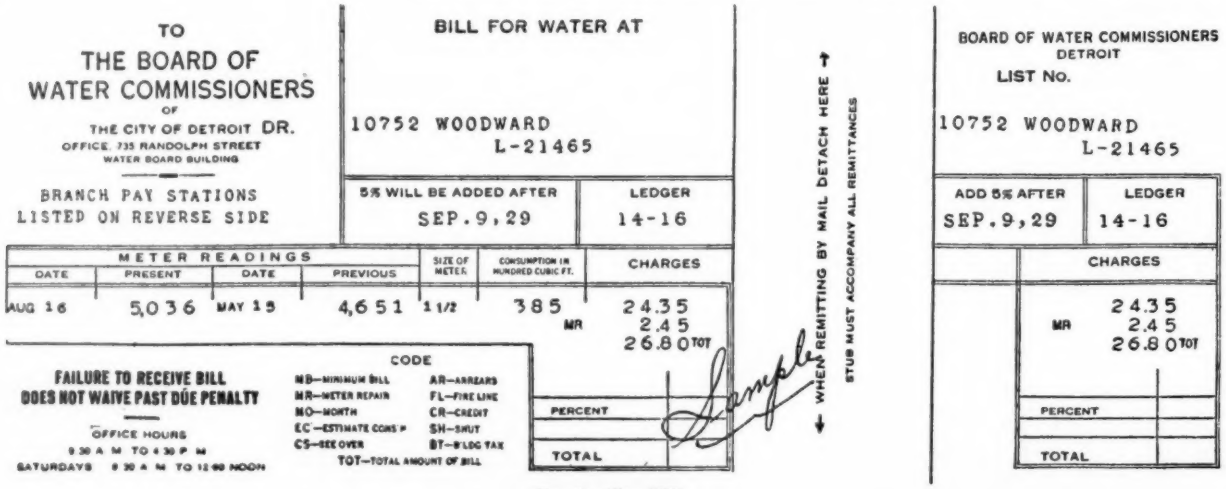


Fig. 2.—The Bill

are posted directly from the trays. The amount of each stub is posted in red ink to the corresponding card by means of a posting machine, which also makes a carbon impression on the proof tape. A transfer total is taken at the end of each control unit and a grand total at the end of each district. The transfer totals of the proof tape are then checked with the transfer totals of the tape run by the night clerk. Should there be any discrepancy it is immediately located and corrected so that at the end of a day's posting the total of the district totals will agree with the cashier's report. No difficulty is experienced in this operation. The tape run by the night clerk, which has been checked with the machine posting tape, is turned over to the control keeper for entry.

We should like to post penalty to all unpaid accounts immediately after due date, but this is impossible on account of bank payments. Most banks, and their branches, are very prompt in making returns, but due to a few, we do not feel safe in posting penalty until twenty days after due date. At this time a clerk, using a posting machine identical to the cash posting machine, except that it is equipped with a black record ribbon, posts the penalty charge to all accounts showing an unpaid balance, and to all accounts paid after due date. A transfer total is taken at the end of each control unit. A proof tape is used on this operation in exactly the same manner as in cash posting, and when the district is completed, the tape is turned over to the control keeper for entry. This operation is a continuous one, posting penalty to one district after the other, in accordance with schedule.

Collecting System.—At this point, collection work breaks into the picture, as the clerk posting penalty, also establishes the shut off list simply by setting aside all cards to which she has posted penalty that carry an item of arrears, indicating that not only is the current bill unpaid, but also all or part of the previous bill.

Our collection system is somewhat unique in that no delinquent bills are sent out. We are operating on the theory that money spent to collect a bill that we have every reason to believe will be paid without collection expense, is just so much money wasted, and further, that a good customer is unnecessarily annoyed. The plan is this: If a customer fails to pay a current bill, there is nothing done about it, provided that the account is paid in full to the current quarter. However, should this account still be unpaid at the time of the next regular billing, the unpaid balance is posted to the bill and the following form attached. If this account is not paid in full by due date, it is pulled by the penalty poster as above explained; a delinquent bill, giving all necessary data is made out and turned over to the Collection Bureau with orders to collect or shut.

All entries to the ledger card made at any time other than the scheduled time for that particular operation, are considered adjustments. All items posted to the control at the scheduled time are reported to the control by proof sheets. All entries made at any other time are reported to the control by adjustment slips. Under the classification of adjustments, then come: final bills, special bills, cancellations, refunds, transfers, and sundry debits. All adjustments are handled by the adjustment clerk, who makes the required entries to the card, writes the adjustment slip thoroughly describing the transaction, and presents it to the head of the bureau, or his assistant for an O. K.

Control Ledger.—You will probably agree that a customer accounting system that is not under complete control and in balance both internally and with the general ledger, cannot be considered satisfactory, no matter how well it appears to be operating otherwise. Our control ledger is entrusted to a senior clerk, acting as control keeper. A master control consisting of 40 controlling accounts, one for each of the thirty-six districts and four for other divisions peculiar to this department, is maintained. This ledger is arranged to show a complete revenue distribution, cash received, and balance outstanding, daily. It is a daily summary of all entries made to customers accounts. The control keeper receives his data from proof sheets and adjustment slips, as above described. A mathematical proof of control entry

Table 1.—Water Distribution Analysis, July 1, 1928, to July 1, 1929

Class Consumers	Rate	Number of Accounts		Consumption Cu. Ft.	Percentage of Pumpage
Domestic	Standard	221,904		3,025,339,091	24.87
Commercial	Standard	22,445		2,450,158,852	20.14
Manufacturing	Standard	1,796		2,307,725,857	18.97
U. S. Government	Standard	21		10,671,000	00.08
Suburban	Double	3,343		1,382,023,100	11.36
Semi-charitable institutions	Half	32		56,690,600	00.47
Water used for construction purposes	Special*	173	Est.	138,067,780	01.13
Charitable institutions	No charge	41		26,641,700	00.22
Municipal—metered	No charge	527		351,642,600	02.88
Municipal—unmetered	No charge		Est.	976,867,100	08.02
Main and service leakage based on pitometer survey			Est.	608,458,300	05.00
Water unaccounted for				834,881,600	06.86
Totals		250,282		12,169,167,580	100.00
Total pumpage in cubic feet				12,169,167,580	100%
Revenue producing pumpage				9,370,676,280	77%
Non-revenue producing pumpage				2,798,471,300	23%
Consumption revenue				$5,244,144.51	85.79%
Service charge				868,707.33	14.21%
Revenue from sale of water				$6,112,851.84	100.00%
Average revenue per 1,000 cu. ft. of total pumpage				$.652	
Average revenue per 1,000 cu. ft. of total pumpage				.502	

*This classification includes C. S., B. T., and Special Assessments. Number of Accounts for Special Assessment only are shown as C. S. & B. T. are not separate accounts but part of Standard Rate and are so distributed.

Pumpage in this report refers to the amount of water entering the distribution system as indicated by the Venturi Meter.

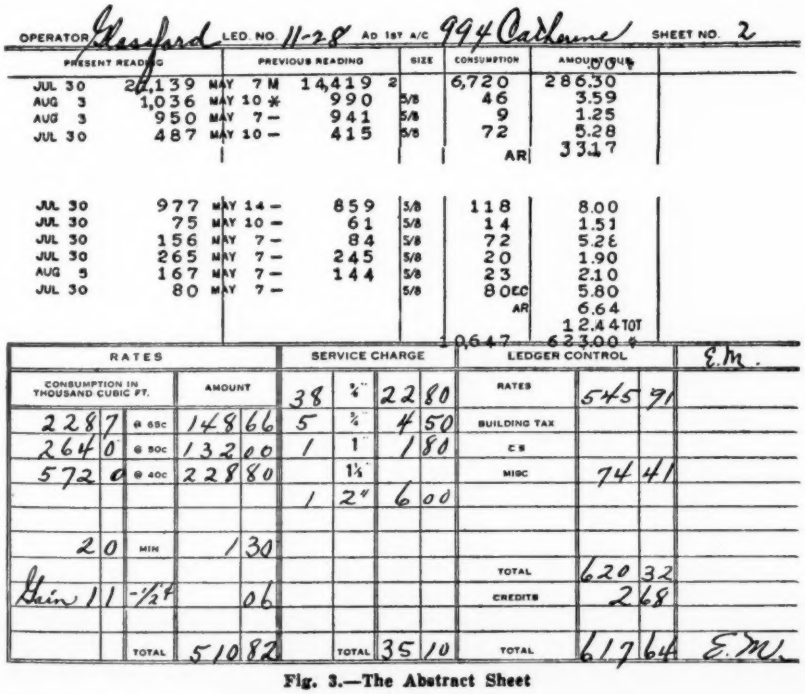

OPERATOR Glassford LED. NO 11-28 AD 1ST A/C 994 Oathame SHEET NO. 2
PRESENT READING
PREVIOUS READING
SIZE
CONSUMPTION
AMOUNT
JUL 30 24,139 MAY 7 M 14,419 2 6,720 286.30
AUG 3 1,036 MAY 10 * 990 5/8 46 3.59
AUG 3 950 MAY 7 — 941 5/8 9 1.25
JUL 30 487 MAY 10 — 415 5/8 72 5.28
AR 3317
JUL 30 977 MAY 14 — 859 5/8 118 8.00
JUL 30 75 MAY 10 — 61 5/8 14 1.51
JUL 30 156 MAY 7 — 84 5/8 72 5.26
JUL 30 265 MAY 7 — 245 5/8 20 1.90
AUG 5 167 MAY 7 — 144 5/8 23 2.10
JUL 30 80 MAY 7 — 5/8 80 ECC 5.80
AR 6.64
12.44 TOT
RATES
SERVICE CHARGE
LEDGER CONTROL
CONSUMPTION IN THOUSAND CUBIC FT.
AMOUNT
38 ¾" 22 80
228 7 @ 65c 148 66
5 ¾" 4 50
264 0 @ 50c 132 00
1 1" 1 80
572 0 @ 40c 228 80
1¼"
1 2" 6 00
20 MIN 1 30
Gain 11 -½% 06
TOTAL 510 82
TOTAL 35 10
RATES 545 91
BUILDING TAX
C S
MISC 74 41
TOTAL 620 32
CREDITS 2 68
TOTAL 617 64
E.M.

Fig. 3.—The Abstract Sheet

has been worked out and is applied daily. It is practically air tight assuring that entries are made in the correct amount, and in the proper place. Each of the district controlling accounts represents about 7,500 customers accounts. This is, of course, too many for balancing purposes, so a control was set up for each reading route consisting of approximately 165 accounts. Since we have at present 1,693 reading routes, it means that we have 1,693 of these sub-controlling accounts, known as route controls. To these accounts are entered only the balance at the last balancing date and the total daily debit and credit items. If the control is accurately kept, it will show balance outstanding in the corresponding route for any given date. If it were known that no error would ever be made to either control or ledger card, trial balances would be unnecessary, but we all know that in spite of all precautions taken to prevent it, errors will occur, hence a periodical trial balance is essential.

Running a trial balance of customers accounts is often considered a difficult and expensive operation; it used to be for us. It is now one of our simplest operations. You will recall that all unpaid balances are posted to the current bill, hence to the proof sheet. The sum of the individual balances for the route is then the outstanding at that time and should check with the control. If it does not, we have only 165 accounts to look through. The error is found in a few minutes, corrected and the controlling account is balanced.

The small control unit and the cycle plan of balancing have made this possible. The route control, acting as a sub-ledger to the master control is kept in balance at all times with the master control, which in turn is kept in balance with the general ledger by means of a monthly trial balance.

The abstract sheet contains a great deal of information readily available for statistical purposes. The compilation and tabulation of these data are daily routine operations.

Acknowledgment.—The above paper was presented before the Central States Section of the American Water Works Association and is reprinted here from the Journal of the Association.

New York City May Spend $500,000,000 on Its Water Supply

New York City is shown to be entering an era in which annual outlays for its future water supply during the next 12 years will be vastly heavier than in any period in its history, according to a survey on public construction prepared by Dr. Leo Wolman, statistician and economist, of the National Bureau of Economic Research. The survey has just been made public by the Committee on Recent Economic Changes of the President's Conference on Unemployment, which sponsored the undertaking.

The survey together with a report of the Committee on Recent Economic Changes have been published by the National Bureau of Economic Research under the title, "Planning and Control of Public Works."

Figures are presented in the survey showing that close to half a billion dollars may be required in the next 12 years to carry out New York City's water supply programs now underway and in contemplation.

Outstanding contracts amounting to more than $40,000,000, for the construction of a delivery tunnel to improve and safeguard the Catskill Mountain supply provide for average annual expenditures of $7,000,000, during the next five years or more than twice the average annual outlay for water supply in the 12-year period between 1907 and 1928 following the completion of the Ashokan dams and reservoir.

In addition to further developments of the Catskill Mountain supply system, New York City, the survey points out, has already taken the first steps in a new program for new sources of supply to be completed within the next 12 years, known as the Delaware River Supply Plan.

The cost of the Delaware River plan, according to figures of the New York City Board of Water Supply quoted in the survey, has been estimated at $273,000,000, the annual expenditures for the project having been scheduled as follows: First year, $3,000,000; second year, $10,000,000; third year, $20,000,000; fourth year, $40,000,000; fifth and sixth years, $45,000,000 each; seventh year, $40,000,000; eighth year, $25,000,000; ninth and tenth years, $15,000,000 each; eleventh year, $10,000,000, and the twelfth year, $5,000,000.

Figures presented in the survey furnished by the Chief Engineer of the New York City Board of Water Supply show that in the period beginning a quarter of a century ago up to the end of 1928, a total of about $184,000,000 was expended for the water supply system of the metropolis, which included the development of the Ashokan reservoir project and other developments of the Catskill Mountain water supply.

In no year during the early period of the Catskill Mountain project, when annual expenditures were heaviest was more than $19,500,000 expended, according to the figures presented in the survey. The contracts for the main Ashokan dams were awarded in the summer of 1907. Water supply contracts close to $100,000,000, were awarded in the years 1907 to 1914. Work on various developments cost the city $228,133 in 1907; $1,877,790 in 1908; $7,713,423 in 1909; jumping to $15,600,268 in 1910; further advancing to $19,104,290 in 1911 and $19,459,970 in 1912; dropping to $15,053,256 in 1913, to $11,026,495 in 1914.

After 1915, when annual costs for water supply construction were $4,309,893, the yearly costs were as follows: In 1916, $1,816,068; in 1917, $815,007; in 1918, $602,054; in 1919, $1,300,993; in 1920, $1,375,705; in 1921, $4,545,769; in 1922, $7,958,751; in 1923, $10,884,181; in 1924, $5,061,581; in 1925, $2,818,278; in 1926, $1,522,292; in 1927, $648,946, and in 1928, $205,545.

An estimated requirement of $483,000,000 in the fifteen year period 1928 to 1942, for New York's water needs, mentioned in "Regional Survey of New York and Its Environs," is referred to by Dr. Wolman as indicative of probable future expenditures.

Record-Breaking Turbine Generators

Two turbine generators that will set several records for capacity and size are being constructed at the Schenectady, N. Y. works of the General Electric Co. for installation in the Hudson Ave. station of the Brooklyn Edison Co., Brooklyn, N. Y. One will be installed in September, 1931, and the other in April, 1932.

Each turbine will be of tandem-compound construction, with double flow in the low-pressure cylinder, and will drive a single generator of 160,000 kilowatts capacity at 0.8 power factor, with a maximum output of 200,000 kilovolt-amperes. The unit is, therefore, the largest single-shaft machine operating at 1,800 revolutions per minute. Without auxiliaries or attachments the combined weight of each turbine and generator will be more than a thousand tons. The turbines are designed for steam conditions of 400 lb. gauge pressure, 730° total temperature, and 1 in. absolute back pressure. Provision is made for bleeding steam at two stages for heating the feed water to a temperature of 270° F. The compactness of the unit is shown by the fact that an output of almost 100 kilovolt-amperes is obtained from 1 sq. ft. of floor area.

The generator that will be driven by this turbine is an outstanding engineering achievement for it is the largest single generator in the world. Rated at 160,000 kilowatts, 16,500 volts and 7,000 amperes, it operates at 1,800 revolutions per minute. As it is an 0.8 power factor machine, the full load output of 200,000 kilovolt-amperes will be considerably greater than the output of the 160,000-kilowatt, 160,000-kilovolt-ampere generator now operating in the East River station of the New York Edison Co. Seventy-one of the new generators, operated continuously for one year, would generate close to 100 billion kiolwatt-hours, which quantity slightly exceeds the total electrical output of the United States for all purposes during 1929.

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Hoover Construction Program Lives Up to Expectations

The success of the Hoover plan of speeding up construction during dull times is now assured. On the last day of June the president announced that for the first six months of 1930 expenditures for public works had exceeded those of the corresponding period of 1929, by 12 per cent, and that a greater excess will occur during the next half year.

He pointed out that it takes time to initiate any marked expansion in so great an industry as the construction industry, for surveys and plans must first be made. He also pointed out that many of the federal appropriations did not become available until July 1.

With a note of pardonable pride President Hoover stated that this is the first time in history that a concerted and successful effort has been made to increase public works expenditures during a business depression. Hitherto cities, counties and states have followed the lead of many private corporations in curtailing construction during "hard times," for outcries were raised against increasing taxes at such times, and the outcries were heeded by the politicians. This time, however, the governors of all the states were invited to join in a nation-wide expansion of public works for the purpose not only of shortening the period of business depression but of providing employment at a time when there would not be jobs enough to go around. Not only were state and municipal heads enlisted in this great economic experiment, but also the heads of railways, public utility companies and large industries. The result has been an expansion of railway and public utility construction analogous to that in public works.

We venture the prediction that this experiment—now well beyond the stage of doubtfulness—will prove to be the most important feature of the Hoover administration. His combined engineering and business experience gave him confidence that construction expansion would serve to restore confidence and thus quickly to renew the usual business activity. Census statistics of unemployment now being made public, show that the percentage of unemployment is much smaller than had been supposed. This also will serve to restore general confidence, for there is no "whistling in the dark" as far as these census data are concerned. The same holds true as to the 12 per cent increase in public works construction.

It will be recalled that in January the forecast was made that public works in 1930 would involve fully a 10 per cent increase over 1929. At the end of the first half of the year, it is seen that that forecast was conservative. So when President Hoover now announces that the last half of the year will show an even greater percentage increase, there should be general rejoicing.

The Blighting Effect of a False Meteorological Theory

More than two centuries ago the scientific study of weather began, yet, aside from the gathering of data, that study has been singularly deficient in theories that are satisfactory. The reason for this barrenness is to be found, we think, in the hold that a false theory has had upon the entire meteorological profession. We refer to the convection current theory. It is beautifully simple, yet as erroneous as very simple theories so often have a way of being.

For every case where the convection theory seems to apply others can be cited where it fails. But where it fails to apply, meteorologists have invented special reasons, or rather excuses, for they have been obsessed with the belief that the convection theory must somehow be sound in spite of many evidences of its unsoundness.

Heat expands air; when expanded its decreased density causes it to float upward, just as a balloon ascends. Cool air flows in to take the place of the hot air that has risen, is in turn heated and ascends. Eventually a "chimney" of heated air may thus be created, and a convection current established. All this is beyond question, but does it explain the air currents that determine the weather? Does it even explain many of the important local air currents?

We are told that the summer monsoons of India are caused by the great "chimney" of hot air in Asia; and that the winter monsoons are caused by the "chimney" of hot air in the Indian Ocean. But Australia is a vast island that is intensely hot in summer, yet has no rain-bearing monsoons in summer such as those of India. Africa is another furnace with no inflowing summer monsoons to bring it such rains as India receives. The entire Pacific coast of North America is heated in summer, yet no summer monsoon rains occur there. The conventional excuse for the absence of strong, wet winds in summer in California is that California is so near to the permanent anticyclone in the Pacific that only dry air is fed into California. Unfortunately for that excuse, that anticyclone is strongest in winter when California gets her rains. Moreover, that anticyclone is too far from British Columbia to affect the climate there, yet British Columbia also is dry in the summer time. Here, then, is a coast several thousand miles long,

not to mention Mexico, that gets no summer monsoons, like those of India. If it be argued that mountain ranges along the Pacific act as barriers, how about the Himalayas in India? That is the highest barrier on earth.

Incidentally "peculiar topography" forms the commonest excuse for failure of the convection theory to apply to a given area. It is noteworthy that winds have no trouble in passing over the Rockies or the Himalayas, and that the summits of mountain ranges show great wind velocities in the windy seasons. A mountain range two miles high seems like a great obstacle until you compare it with a height of 20 miles or more. When Krakatoa exploded in 1884 dust at an elevation of 20 miles was carried three times around the earth at a velocity of 70 miles an hour by the general air current. To such air currents a range of mountains is little more than a ridge of pebbles in the bottom of a river.

Differences in barometric pressure are constantly cited by meteorologists to account for the flow of air from one area to another. Yet the greatest of such differences often exist between a cyclonic whirl and a sequent anticyclone, without the slightest evidence of a surface flow of air from the "high" to the "low." If it be replied that the distance between their centers is so great that the barometric gradient is not sufficient to overcome the friction, then such an answer itself destroys the entire theory of convective air currents of a general nature, for the barometric gradients are always slight. In fact they are so insignificant that a hydraulic engineer should be reluctant to believe that they explain the rapid air currents that often exist.

Perhaps the most fantastic of the applications of the convection theory is to be seen in its use to explain cyclonic storms. "Chimneys" of hot air are supposed to be localized sufficiently to start a strong ascending current; then the air chimney is supposed to drift with the general air current. As it drifts toward lower latitudes centrifugal force is supposed to give it an anticlockwise whirl in the northern hemisphere and a clockwise whirl in the southern hemisphere. But nearly every great cyclonic whirl is followed by a great anti-cyclonic whirl turning in the opposite direction, so what becomes of the centrifugal force theory as an explanation of the direction of these supposedly independent whirls?

We believe that barometric pressure differences are the effects and not the causes of most air currents. The air at times is heavily charged with electrons, and in that condition its electrons rotate around magnetic lines of force. Thus are both the permanent and the migratory cyclonic whirls created. An anticyclone is the descending end of a U-shaped air-whirl of which a cyclone is the ascending end. We believe that practically all air movements are due to such whirls. Migrating cyclones push air in front of them, acting like pistons. Stationary cyclones draw air inward, whereas stationary anticyclones expel air. The great system of air currents is generated by electronic forces and not by barometric pressure differences.

Not until the convection theory is completely displaced by the electron theory will long-range weather forecasting become possible. Long-range forecasting has been the real goal of meteorologists for two centuries, but the old false theory has latterly made that goal seem unattainable for many a century yet to come.

Man's Most Important Invention

Perhaps the most important of all inventions is the wheel and axle. The earliest records of wheeled vehicles are Egyptian. It is possible that the Chinese wheel-barrow was invented prior to the Egyptian two-wheel car or chariot.

Since mountain roads in Egypt were often only 4 ft. wide, their cars must have been very narrow. In going through Pompeii one is impressed by the exceeding narrowness of the streets, and especially of the parts that formed the roadway for chariots. In most instances this roadway is wide enough for only one narrow vehicle. At a street intersection there are high stepping stones, one of which is between the grooves worn in the pavement by the wheels, this stone being high enough to avoid stepping in the muck that probably existed in the trackway, but low enough to clear the axles of the chariots and carts.

In Naples, even today, two-wheel carts predominate, which probably indicates that four-wheel vehicles, at least for trucking purposes, are relatively modern.

In China there is only an insignificant mileage of roads wide enough for the use of motor cars. Narrow as were most of the Egyptian and Roman roadways for vehicles, those of China were narrower, probably because horses were not used. Even now the horse is not commonly used in China. China will doubtless pass directly from man-power to gasoline-power in vehicle propulsion, but the change will be rendered exceptionally difficult because of the narrowness of the roadways.

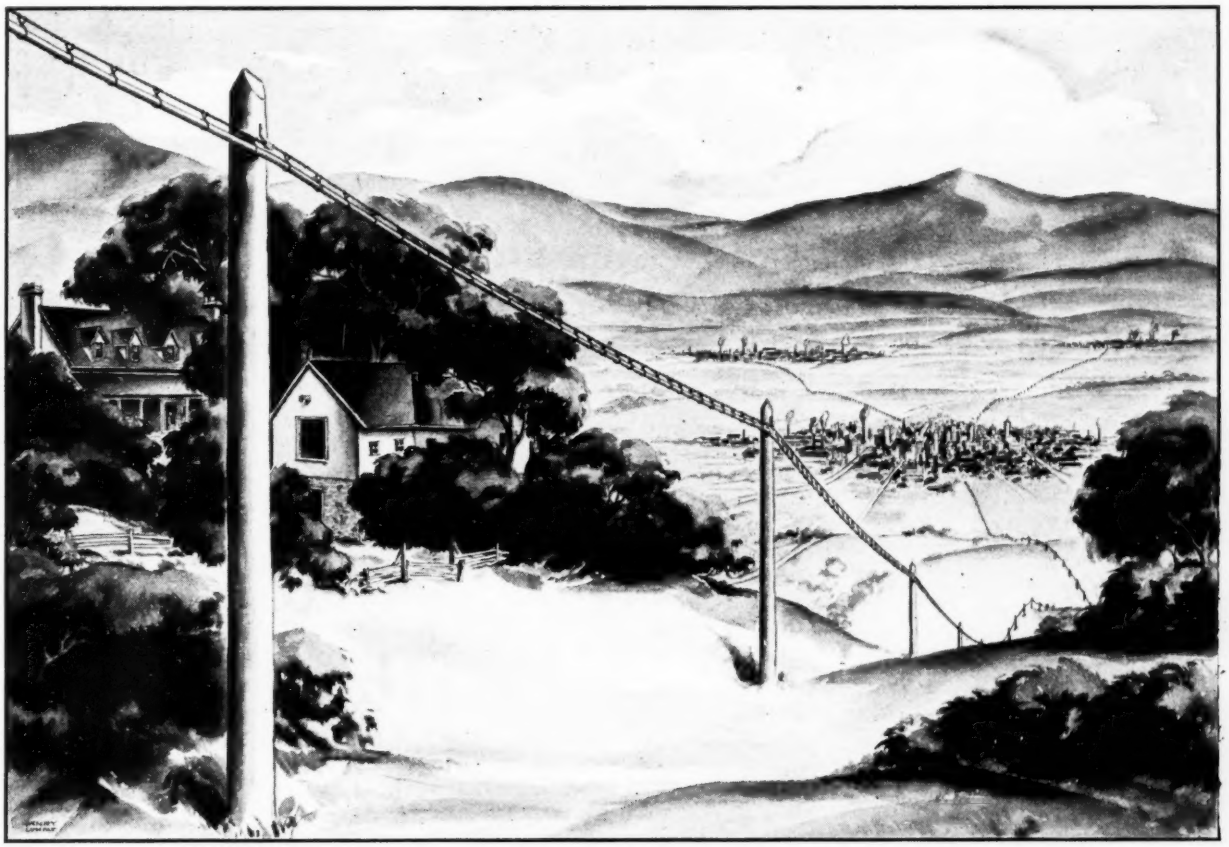
Flanged wheels on iron rails were first used about the year 1800, the invention being that of William Jessop of England. This marked the next great invention associated with the wheel and axle.

Next came an invention of supreme importance, the pneumatic tire. In 1843 an English civil engineer named R. W. Thompson patented this device for use on horse-drawn vehicles. It was never much used until the advent of "the safety bicycle" about 40 years later.

"The ball-bearing, invented by an Englishman named Bonn, is another epoch-making invention," says the Encyclopedia Americana under Bicycle, although it fails to list this important invention under Inventions where a chronology is given of the most important inventions since 1620. Incidentally it may be added that no biographical sketch of Bonn, Thompson or Jessop is to be found in either the Americana or the Britannica. Hence three of the most important inventors in the history of the wheel have received no biographical recognition by the two most commonly used encyclopedias. When these omissions are contrasted with the thousands of biographical sketches of men who did nothing but talk, one is impressed with the idea that the talkers still rank higher than the doers in the estimation of the encyclopediaists.

Not long ago we had occasion to look for a sketch of the German who invented wood-pulp paper, but could not find it. He may have got his great idea from examining wasps' nests, as the story goes, but since no other human-being in the long history of mankind had wit enough to take an industrial hint from those fiery but ingenious insects, one would expect at least an inch of typed information in the encyclopedias about that man.

H. P. Gillette



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DISTRIBUTOR NEWS

The Distributor's Department in the Gillette Construction Group

Michigan Valve & Foundry Buys Columbus Valve

The latest step to be announced in the expansion program of the Michigan Valve & Foundry Co. is the acquisition of the business, plant and assets of the Columbus Valve & Manufacturing Co., of Columbus, O., makers of plug type valves.

The Michigan Valve & Foundry Co. are licensees under the Meehanite metal patents, and the desirable physical qualities of Meehanite, will be utilized to extend the working range of both plug valves and gate valves.

The Columbus plant will continue to be used exclusively for plug valve production, while the gate valves, sluice gates and other Michigan products will be handled by the Detroit plant, it is said. The operations of both plants will be directed by Mr. R. J. Goldie, the company's general manager. Executive offices remain in Detroit.

F. D. West Made Sales Manager for Paradon

Announcement has been made of the appointment of Mr. Francis D. West as manager of sales for Paradon chlorinators, with headquarters at Arlington, N. J.

Mr. Francis D. West

Mr. West, for a number of years, was chemist in charge of the Torresdale Filter Plant, Water Department, Philadelphia, which city was among the first to use chlorination on a large scale.

For the past ten years Mr. West has been manager of sales for the Permutit Company in the territories of northern and western New York State.

Another item of interest concerning this company is the opening of an office at Pittsburgh, Pa. Mr. Ray S. Palmer is to be the representative in charge. By the new arrangement the Paradon Company will have increased facilities available for the sale and service of their products in Western Pennsylvania, Ohio and West Virginia territories.

Mr. Ray S. Palmer, to Head Pittsburgh Office of Paradon Mfg. Company

Roessler & Hasslacher Hold Sales Meeting at Niagara

Executives from the manufacturing plants and offices, together with sales force and service men, met recently at Niagara Falls to discuss the manufacture, service and sales of Roessler & Hasslacher products. Dr. H. R. Carveth, president of the company, was chairman of the convention meetings. Mr. J. E. Hatt, general manager of the duPont Cellophone Co., was the speaker at the annual banquet, which was held at the General Brock Hotel, Niagara Falls, Ontario.

Representatives from the various branches of the company in the United States, Canada and Mexico were in attendance.

American Steel & Wire Goes "Talkie"

One of the first successful "Talkie" industrial motion pictures has been produced by the American Steel & Wire Company, a subsidiary of the United States Steel Corporation.

Featuring a trip through the mills in which Wire Rope is made, the entire process becomes not only visible on the silver screen, but the illusion of actually being present is increased by the introduction of sound.

As each stage of manufacture is viewed, it is orally explained in a detailed and impressive manner. In this way many important points of interest, impossible to cover in the usual screen captions, are conveyed to the listener.

An added and novel feature is the use of lively music at certain spots where the action does not require conversation. This combining of entertainment with educational factors has proved unusually effective in maintaining interest to the highest possible pitch.

Although the adaptation of sound to industrial films is new, the remarkable success of this venture foreshadows a widespread use.

Simplex Valve Appoints Goldsborough & Vansant

The Simplex Valve & Meter Co. announces the appointment of Goldsborough & Vansant, Inc., Farmers Bank Building, Pittsburgh, as district representative for the Pittsburgh territory.

Mr. C. C. Behney, who formerly represented the Simplex Valve & Meter Co. in this territory, has been assigned to special work.

Announcement

The Board of Directors of Jenkins Brothers announces the election of Mr. James R. White as vice-president of the corporation and also his appointment as director of sales. This company, which is located at 80 White St., New York, is a well-known manufacturer of valves.

The Chicago Pump Co., of Chicago, announces the addition to their list of representatives of Mr. R. J. Welsh, 503 Healy, Atlanta, Ga.

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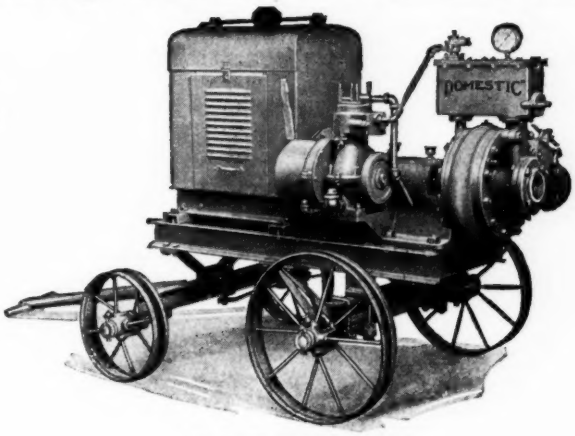

Fig. 857—VC-3T Unit

Ball Bearing Shaft —Extra Heavy

Open-passage, Wide Trash Handling Impeller —special design

Ample Power—10 hp. 4 cyl. Radiator-cooled Engine

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Write today for descriptive bulletin and name of nearest dealer.

DOMESTIC ENGINE & PUMP CO., Manufacturers, Shippensburg, Pa.

W. H. Searight Joins Sales Force of Joy Mfg. Company

Mr. William H. Searight, for several years with the American Gas Accumulator Company as western manager, has recently joined the staff of the Joy Manufacturing Company, Franklin, Pennsylvania, as assistant sales manager in charge of snow loading and surface material handling development.

Mr. Searight, it is said, will devote his entire time to the development and sale of surface loaders carrying the Joy gathering device now used in under ground coal mines.

Hanson Made Paradon Export Manager

Announcement has been made of the appointment of Mr. Wilmer C. Hanson as export manager for the Paradon Manufacturing Co. of Arlington, N. J., makers of water purification equipment.

Mr. Hanson has been engaged in the export business all his life, specializing in engineering and water works specialties. He was formerly connected with George Nolan & Co., exporters of engineering equipment to South America. In his new position he will be located at 30 Church St., New York City.

Announcement

Mr. Stuart R. Ives, vice president and general manager of the Lyle Culvert & Pipe Company, Minneapolis, has been appointed general manager of the Armco Culvert Manufacturers Association, with headquarters at Middletown, Ohio.

Mr. Lyle comes to his new position with a background of many years of intimate contact with the culvert industry and with the problems of the road builder, the public official and the engineer in charge of drainage work.

In announcing the appointment of Mr. Ives, the Armco Culvert Manufacturers Association states that the aims and policies of the association will continue to be: "Thorough-going research in all matters pertaining to drainage, engineering assistance in the solution of specific drainage problems and educational publicity to bring the results of the association's work to the attention of those who can profit from it."

Cutler-Hammer Announces Merger

Announcement has been made by Cutler-Hammer, Inc., Milwaukee, Wis., of the acquisition of Schweitzer & Conrad, Inc., Chicago, manufacturers of high voltage equipment.

Mr. Beverly L. Worden, president of Cutler-Hammer, has been elected president of Schweitzer & Conrad, which is the only personnel change resulting from the merger. It is stated that the company purchased will continue to operate as an independent manufacturing and selling unit.

In adition to Mr. Conrad and Mr. Schweitzer continuing as members of the Board of Managers, Mr. F. R. Bacon, Mr. F. L. Pierce and Mr. Louis A. Lecher, all members of the Cutler-Hammer board, now become members of the board of Schweitzer & Conrad.

Hercules Modernizing Carthage Plant

Nine new buildings, modern in design and equipment, are to replace thirteen small buildings in the Carthage plant area of the Hercules Powder Company, according to recent announcement. Estimated cost of improvements is placed at $175,000. Removal and installation of material and machinery will account for much of the cost incurred.

It is stated that contracts will not be awarded because of the company's ruling regarding the number of men working in explosive areas. Installation is being carried out by Hercules employes under the direction of plant superintendent, J. S. Marks of Carthage, and construction engineer, R. K. Hallett of Wilmington, Delaware.

Army Officer Joins Budd

The Edward G. Budd Manufacturing Company, of Philadelphia and Detroit, makers of all-steel bodies and body parts, announces the appointment to its Detroit sales force of Colonel George A. Mix. At the close of the war Colonel Mix resigned from the regular army and has since been connected with the Auburn Automobile Company and the Chrysler Motor Company.

T. A. Burns Joins Harnischfeger Co.

Mr. T. A. Burns, who has had wide experience in selling the larger sizes of excavators, has joined the sales organization of Harnischfeger Corporation. He will work directly out of the general sales department in the home office at Milwaukee.

The Buhl Company, manufacturers of the Buhl portable air compressor, is pleased to announce the appointment of the H. O. Penn Machinery Company, 140th Street and East River, New York, as distributors in the New York district.

The H. O. Penn Machinery Company carries a complete line of these compressors and parts in stock. They will give the usual Penn service.

G. H. Williams Company announces the appointment of Kratz & McClelland of San Francisco as agents for the northern California territory. Complete stocks will be carried by the distributing company. The Williams Company is located at Erie, Pa., where the "Champion" buckets and "Arch-Girder" trailers are manufactured.

Hercules Motors Corporation of Canton, Ohio, reports a nice business on engines in Japan, where K. Hattori & Company, Limited, of Tokio serves as exclusive representative on Hercules products.

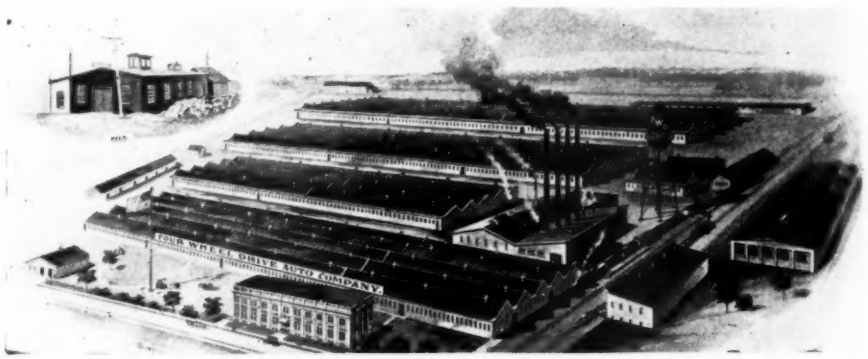
C. H. Redman Joins FWD Staff

Mr. Charles H. Redman, formerly with the Ferro Machinery and Foundry Company, Cleveland, Ohio, has joined the Four Wheel Drive Auto Company's engineering staff to devote his time to the study of adaptation of their trucks to special and unique services. Mr. Redman is a graduate of the Michigan School of Mining Engineering at Houghton.

Announcement

Mr. A. Manzone has been elected president of the Rich Art Color Company, Inc., of New York City, according to recent announcement. For many years past Mr. Manzone has managed the American sales office of Pelican Works, manufacturers of drawing inks and artists' materials. The Rich Art Color Company, under Mr. Manzone's management, will continue the sale of the Pelican products.

Service Exchange has been helpful in securing desirable representation for the products of many manufacturers and in assisting distributors in building up their lines. Do not hesitate to make use of this service which the publishers present as a regular feature of this magazine. For information write, Editor, Distributor News.



1930 plant at Clintonville, Wis., headquarters of FWD Auto Co., showing increase since 1910

Pomona Turbine Pump installed for the City of Joliet, Illinois.

last month...

48 Municipalities

SELECTED POMONA PUMPS

Health and sanitation are but two of many reasons why 48 municipalities purchased Pomona Turbine Pumps last month. City engineers everywhere have conceded that water-lubrication is superior for municipal water production. In response to an inquiry one director of the health department in a large American city states in part: "We are of the opinion that submerged oil-lubricated bearings should not be used in connection with drinking water supplies." Goodrich Cutless Rubber Bearings with water-lubrication is standard Pomona construction. Complete specifications and Bulletins sent on request.

Distributors and sales-service offices in all principal cities, write for name of nearest one.

Pomona Pump Co., Pomona, Calif.

POMONA

WATER LUBRICATED TURBINE TYPE

Oceans of Water

PUMPS

[Ask for Catalog]

These Sludge Bed Enclosures Join the Floral Business After 13 Years Service With the City of Alliance Ohio

A Bigger Range of King Enclosures Takes Their Place in the New Alliance Disposal Plant . . . "In Splendid Condition," Says the New Owner About the Used Range

To meet the needs of an ever-swelling population, the City of Alliance found it necessary to abandon the sewage disposal plant built in 1917 and construct a larger one in a new location.

Larger sludge beds were needed, and a bigger range of Kings to cover them. . . . And were the old Kings junked?

Never! A prominent Alliance florist bought and added them to his range. Every house was in first-class condition despite the long service under strenuous conditions.

The new King Enclosures in the recently completed Alliance Disposal Plant are veritable models—solving the odor objection and more than doubling the capacity of the beds. Do you want the story describing the Alliance plant in its entirety? Write. (Literature will be included.)

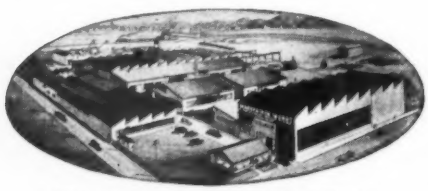
KING CONSTRUCTION COMPANY

533 Wheatfield Street
North Tonawanda, N. Y.

NEW YORK CITY PHILADELPHIA, PA. BOSTON, MASS.
SCRANTON, PA. TOLEDO, OHIO SCHENECTADY, N. Y.
BRIDGEPORT, CONN.

National and International Distribution Announced for Madsen Iron Works

Until now the Madsen Iron Works, makers of portable asphalt plants, has confined its operations to west of the Mississippi, but announce negotiations are now in progress for establishing adequate representation in the principal European centers, and sufficient interest in their eastern plants to justify plans for national distribution.



The Madsen Iron Works, Huntington Park, Calif.

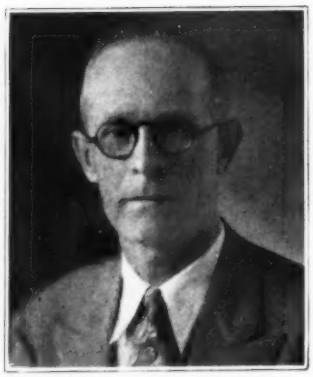
Twenty years ago Martin and Peter Madsen established their first iron foundry on a leased city lot with fifty feet of frontage. Today the Madsen Iron Works occupies its own site of five acres in Huntington Park (a suburb of Los Angeles), California, and the original staff of six people has grown to 200. It is said that the building of the first Madsen plant was the work of almost a year, whereas today a complete 1,000-lb. plant can be turned out in from three weeks to thirty days.

During the first ten years this organization engaged in making units for "stick" plants, but in 1920 they built their first complete, all metal, wholly portable plant bearing their name. This first plant was of 1,000-lb. capacity, according to Western plant rating, and was purchased by the

K. A. Richardson, Sales Manager

Southwest Paving Company of Los Angeles. Today this manufacturer is making portable tower plants in capacities up to 6,000 lb. per batch. Distribution of these plants is now reported not only in North and South America but in far away Russia.

The Madsens are said to have patented and retained control over many features of their paving plants. Mr.



Mr. Martin Madsen, President, Madsen Iron Works

Martin Madsen, president of the company, is chief of the paving plant division. K. A. Richardson, a graduate engineer, is sales manager, and A. H. Ziegler, chief engineer.

A. H. Ziegler, Chief Engineer

Distributing companies include: Edward R. Bacon Company, San Francisco; Western Road Machinery Company, Portland, Ore.; Olympic Machinery Company, Seattle; Stannard Machinery Company, Salt Lake City, Utah; H. W. Moore Equipment Co., Denver, Colo.; Wm. H. Ziegler Co., Inc., Minneapolis, Minn.; George W. Smith Company, Dallas, Texas; W. R. Grace & Company, operating throughout South America, are at present their most important foreign distributors.

Notes from House Magazines

The most recent "Sauerman News" to reach us might almost be called the "foreign edition," for it contains some interesting stories about installations of slackline cableways and scrapers for meeting excavating and materials handling difficulties in England, New Zealand and Brazil. So, with the references to construction work in our own Black Hills in Wyoming, four continents are visited and interesting pictures accompany each story.

The work in England and the British Colonies was under the direction of the English engineer, Mr. E. F. Sargent of Skelton, York.

The South American stories concerned the work of the Bahia Corporation in diamond-bearing gravel to secure carbonado, or black diamonds used for drills and other important industrial uses. This is an American corporation formed in New York by Arthur S. Bandler, who serves as president. David Bandler is vice-president and treasurer, Thomas J. Ward, secretary, and A. P. Rogers, a mining engineer of long experience, is general manager.

The construction work as described at Bahia was in charge of A. D. Hughes and a staff of expert assistants, among them Harold D. Douglas, John Moline, who had charge of erection and installation of cableways, and Simpson Watt of the Westinghouse company, in charge of electrical installations.

This interesting story was told in the "Sauerman News," published by Sauerman Bros., Inc., Chicago.

* * *

Pipe information historically told is the way of the little U. S. Piper, of the United States Pipe & Foundry Co., and it makes fascinating reading both concerning the cast iron pipe and the history. For what's being done in the East read about the old traditionally interesting town of Frederic, Md., if longing for the wide open spaces Durango, Col., installs a model water system and takes its pure water from the Rocky Mountain snow fields. That isn't all the Piper talks about either and it's all good reading.

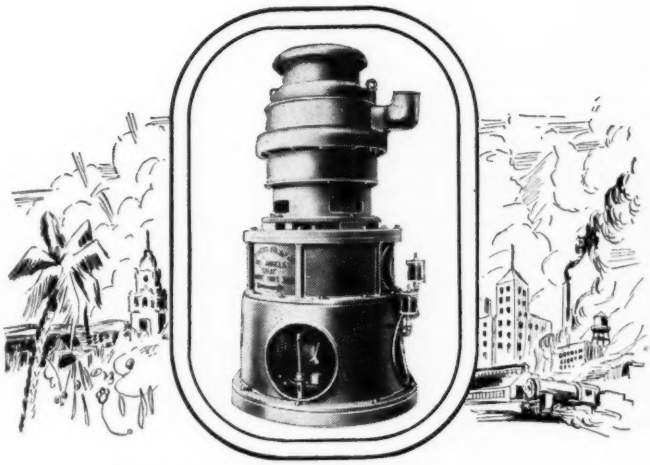
* * *

"All dressed up" were the Schramm compressors shown in the last "Bores and Strokes" from West Chester, Pa., for they appeared surrounded by ferns and hanging flower baskets in the booth of the Metal Union Ltd. display at Public Works Exhibition, Agricultural Hall, London, England.

* * *

Some of us know about old clothes turned inside out, and "turning clouds about to see the lining" has been told in song and story, but turning pavements upside down is something else again. "New Pavements from Old" is the title of an article by Herman Geiser telling of turning brick pavements over for the city of Lima, O. It appeared in "Dependable Highways," the publication of the National Paving Brick Manufacturers Association of Washington, D. C.

International Filter Co. and associated companies, International Water Softener Co. and General Zeolite Co. announce the removal of their general offices and engineering departments from Plant No. 1 at 333 W. 25th Place, Chicago, to larger quarters covering the 13th and part of the 14th floor of the Buckingham Building, at 59 E. Van Buren St. The change was made in order to increase manufacturing facilities.



The Choice of Cities

Dependable water supply being highly essential to municipalities, it is only natural that so many of the city engineers, who have thoroughly investigated the functions dependent upon efficient pumps, should specify PEERLESS to insure satisfactory service with the least maintenance expense.

Illustrated literature free upon request. No cost or obligation—just write Department W.

Peerless Pumps

YOU CAN ALWAYS DEPEND ON A PEERLESS—ALL WAYS

PEERLESS PUMP COMPANY

Executive Offices: 1902 E. 67th St., Los Angeles, Calif.
Factories: Los Angeles, Calif., Massillon, Ohio
New York Office: Room 513, 51 E. 42nd St. Massillon Office: 302 Walnut Avenue, S.W. Chicago Office: Room 410, 9 So. Clinton St.

DISTRIBUTORS IN ALL PRINCIPAL CITIES

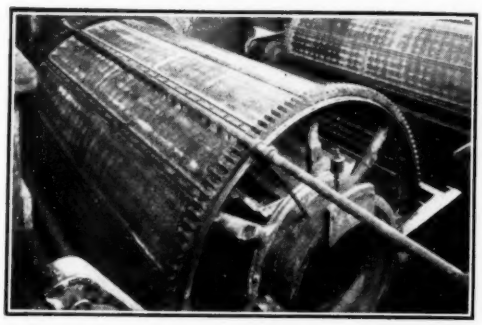
It's what you get out of them
THAT COUNTS

You can buy tool boxes *and* tool boxes. The thing uppermost in your mind is, "Will this tool box serve our purpose?" If you intend to purchase one tool box or a lot of them, by all means, let us send you a full description of our new All-Steel Utility (Splicer) Box—made for water works maintenance departments. Compare it with other boxes.

LB — STEEL BOXES FOR EVERY PURPOSE — LITTLEFORD BROS. CINCINNATI, O.

LITTLEFORD
ALL-STEEL
TOOL BOXES

LITTLEFORD BROS. 422 E. PEARL ST. CINCINNATI, O.



At Plankington plant

The North Sewage Screen

A clarifier which removes and aerates the effluent. Liquids go through perforations finer than a cambric needle.

Saves byproducts in a dry state.

Doubles capacity of old sewage plants. Decreases cost of new disposal plants.

Is all you need if effluent discharges into large streams.

The only *fine* screen on the market.

GREEN BAY FOUNDRY & MACHINE WORKS
GREEN BAY, WIS.

"NO VISIBLE SOLIDS IN EFFLUENT"

POWERFUL
POSITIVE-PRACTICAL

Double Lid Cover

Ideal for colder climates. Protects meters from freezing.

Single Lid Cover for milder climates where less protection is necessary. Neat, unobtrusive.

There are 25 types and sizes of Ford Meter Box Covers—All have The Ford Worm Lock.

It locks the lid securely—
It lifts the lid on unlocking—

Hundreds of thousands are in service.

Write for Catalog

The **FORD METER BOX** *Co.*
WABASH-INDIANA
WATER METER SETTING & TESTING EQUIPMENT

SERVICE EXCHANGE
For
Manufacturers or Distributors

Editor's Note.—From time to time we receive letters from distributors wishing to be put in touch with manufacturers of certain lines of equipment, or from manufacturers seeking representatives for their products. Items of this kind will be published and names and addresses furnished interested persons upon request.

New Lines Wanted

Manufacturer's representative now handling centrifugal pumps would like to secure other lines in water works field. Covers eastern Pennsylvania, south Jersey and Delaware.

Water Works equipment distributor, covering northeastern Indiana, would like to secure represenation of a line of chlorinators.

Manufacturers' agents representing well known lines of water works equipment desire to secure line of pipe pushers and other similar equipment for California and western Nevada territory.

Distributor covering northern California, having warehouse facilities, would like to secure line of water meters, pipe jacks or pushers, flow meters, and sewage treatment and disposal material and equipment.

Bacteriologist would like to make connection with manufacturer for such work, or as assistant chemist.

Canadian distributor of equipment for water softening, filtration, sewage purification and pumping is interested in securing exclusive sales rights for kindred equipment in the Dominion.

West Coast distributor, specializing in materials for sewers and water works, is in a position to render splendid representation for territory covered.

Manufacturer's representative, with warehouse facilities available, would like to secure additional lines in water works and sewerage and general contracting fields. Covers Houston and San Antonio territory.

Wanted for Buffalo, Niagara Frontier and Western New York territory a good power and heating boiler account.

Distributor of building specialties covering a territory of 100 mile radius from Chicago is equipped to represent additional lines.

Manufacturer's representative, covering Massachusetts, Rhode Island and southern New Hampshire, would like to secure line of speed reducers and gears.

Manufacturer's representative with 25 years sales experience, conversant with all types of pumps and their field, desires agency for either New York or export territory, or both.

A Michigan distributor, with many years' experience, representing at this time prominent manufacturers of pumping machinery, offers the services of an established representative to manufacturers needing increased facilities in this region.

Representatives Wanted

Manufacturer of special valve and hydrant lubricant wishes to establish distributing points throughout the country.

Manufacturer of centrifugal pumps for water works, sewage plants, sand and dredging plants, process industry, contractors, etc., desires to secure additional representation. Attractive territory available.

Well established manufacturers' representatives wanted to handle sand and gravel pumps and equipment, in key cities, by successful manufacturer of high grade dredging pumps and hydraulic dredging equipment. Give character of equipment now being handled and territory covered.

Manufacturer of threadless pipe couplings and tees, with rapidly growing business, is seeking additional representatives.

Manufacturer of non-clogging sewage pumps, both horizontal and vertical, as well as water works pumps suitable for municipalities of 50,000 or 60,000 people, is interested in securing additional sales representation.

Distributors wanted for deep-well turbine pumping unit. Product serves small industrial plants, private estates and farmers.

Manufacturer of water works brass goods would like to make proposition to manufacturers' representatives calling on water works' trade.

District representatives wanted for sanitary engineering specialty used extensively in the water works, sewage and swimming pool fields.

Attractive territory available for experienced men to handle contractors' labor-saving equipment by old established company. Equipment backed by national advertising.

Manufacturer of complete line of construction equipment, mixers, saw rigs, plaster and mortar mixers and pumps has an open territory in the state of Maine and is looking for an aggressive distributor to represent him there.

Long established and well-known manufacturer of industrial locomotives wishes to make contacts with qualified distributors. Locomotive line includes steam, gasoline, gas-electric and oil-electric. Supported by national trade journal advertising.

Manufacturer of air compressors and contractors' tools has number of desirable territories open. Full co-operation will be extended to distributors.

Distributors wanted to represent improved type of snow fence. Good territory in various parts of country.

Manufacturer of contractors and builders levels and transits is seeking district sales manager. Exclusive contract given. Excellent territory still available. Backed by national advertising.

One of the leading manufacturers of surveying instruments in the United States is seeking responsible agents in all sections of the country. Instruments are nationally advertised in all leading engineering journals.

Manufacturer of patented reflecting signs and devices desires representative for New York City, Long Island, Westchester County and adjacent territory. Some one selling other products to municipalities preferred.

Manufacturer of patented luminous highway danger signs and signals is interested in securing aggressive representation in various parts of this country and Canada.

Manufacturer of metal tie and spacer wishes to establish distributing points throughout the country.

Machines desires to build up distribution organization in this country and abroad.